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MARCH 1956 VOLUME 72 NUMBER 3

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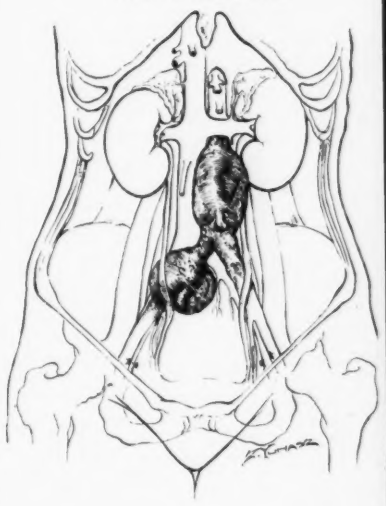

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The Journal of the American Medical Association. Weekly. Annual Subscription Price: Domestic, $15.00. Canadian, $17.00. Foreign, $21.50. Price to students, interns, and residents: $9.00 in U. S. & possessions.
Quarterly Cumulative Index Medicus. Issued Twice a Year. Subscription Price, Calendar Year, $25.00.

Checks, money orders, and drafts should be made payable to the American Medical Association, 535 North Dearborn Street, Chicago 10.

Published Monthly by

AMERICAN MEDICAL ASSOCIATION

535 NORTH DEARBORN STREET • CHICAGO 10, ILLINOIS

Entered as Second Class Matter July 10, 1925, at the Postoffice at Chicago, Under the Act of March 3, 1879. Annual Subscription, $14.00

A.M.A. Archives OF SURGERY

Tetracycline (Achromycin)-Neomycin for Preoperative Colon Preparation

ISIDORE COHN Jr., M.D., D.Sc. (Med.)
and
ALFRED B. LONGACRE, M.D., New Orleans

In the course of a systematic study of the various agents available for preoperative preparation of the large bowel,* one agent has given such superior results that we feel justified in reporting it separately at this time.

The combination of tetracycline hydrochloride (Achromycin)-neomycin and the usual mechanical aids to bowel cleansing has come closer to true sterilization of the feces than does any other agent or combination of agents tested. The absence of the disturbing gastrointestinal reactions that so frequently accompany the broad-spectrum antibiotics when given in dosage which is adequate for bowel sterilization was an additional advantage. The outgrowth of yeasts, frequently blamed for many of the disturbing side-effects, does not reach significant proportions until the last day of preparation and therefore should not cause trouble. The return of the usual fecal flora, with its attendant decrease in yeast count, has been another point in favor of this method of bowel preparation.

The over-all results with this type of bowel preparation have been so satisfactory that it has been adopted as the standard method of bowel preparation for all patients undergoing elective colon surgery on our hospital service.

METHODS

Patients were selected at random from the Louisiana State University Surgical Service of the Charity Hospital at New Orleans. The only requirement was that they not have any known disease of the gastrointestinal tract. They were placed on a low-residue diet, were given daily enemas, were given a cathartic the first day of the program, and were given the tetracycline hydrochloride-neomycin combination as follows: tetracycline hydrochloride-neomycin—four tablets every hour for 4 hours, then four tablets every 6 hours for a total of 72 hours.

Each tablet contains tetracycline hydrochloride 50 mg. and neomycin 250 mg.; hence, the unit dosage was 200 mg. tetracycline hydrochloride and 1.0 gm. neomycin.

Quantitative bacteriologic analyses were conducted on the stools as follows: control, each day of therapy, and the third and fourth days after the end of therapy. This evaluated the rate of return of the bacterial flora after discontinuation of the drug.

BACTERIOLOGIC TECHNIQUES

One gram of stool was diluted serially with sterile water to the following dilutions: 10^{-2}, 10^{-4}, 10^{-6}, 10^{-8}, and 10^{-10}. From each dilution 0.05 ml. was inoculated into the following culture media:

Five plates blood agar (trypticase soy-agar base with 4% agar, 5% human blood-bank blood), incubated aerobically.

Submitted for publication July 18, 1955.

Aided in part by a grant from the Lederle Laboratories Division of the American Cyanamid Company.

Department of Surgery, Louisiana State University School of Medicine, and Louisiana State University Surgical Service, Charity Hospital of Louisiana at New Orleans.

* Unpublished observations.

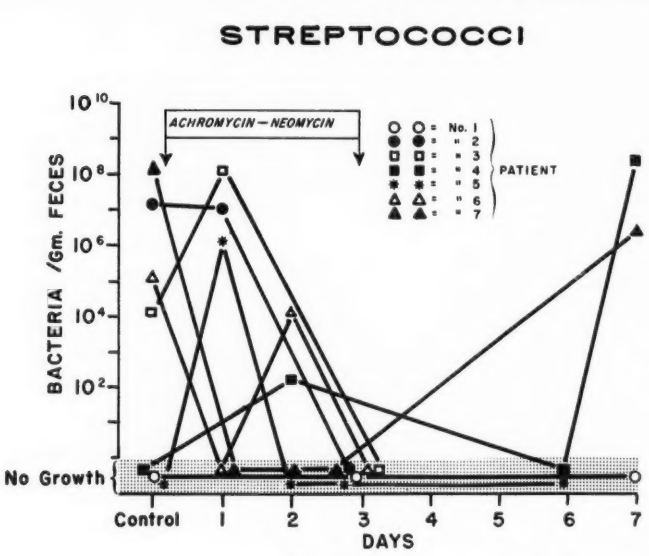


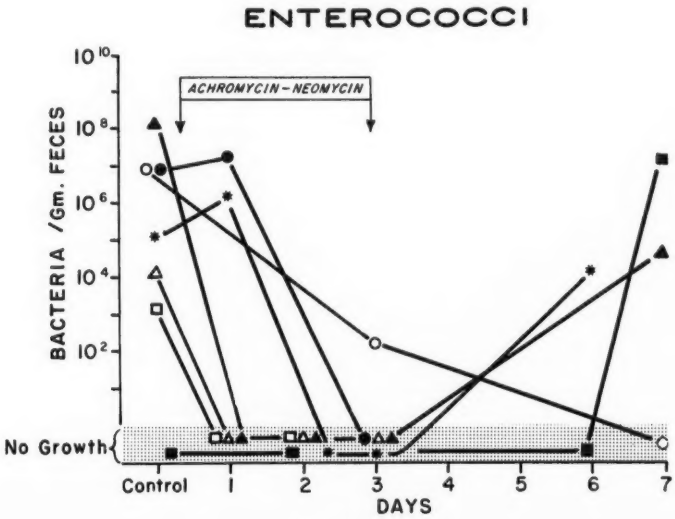
Figure 1.

Five plates blood agar (same as above), incubated anaerobically (hydrogen method).

Five plates MacConkey agar, incubated aerobically.

At the appropriate intervals the plates were counted and organisms identified through Gram-stain smears and subcultures. Subcultures were made from aerobically incubated blood plates at 24 and 48 hours by inoculation into brain-heart infusion broth and on eosin-methylene-blue agar. These subcultures were examined at 24 hours and Gram-stained. Heat and catalase tests were performed and further inoculation made as necessary into differential media.

Subcultures from the anaerobically incubated MacConkey plates were made on eosin-methylene-blue agar, and, if further identification was necessary, biochemical reactions were observed after the inoculation into other media.



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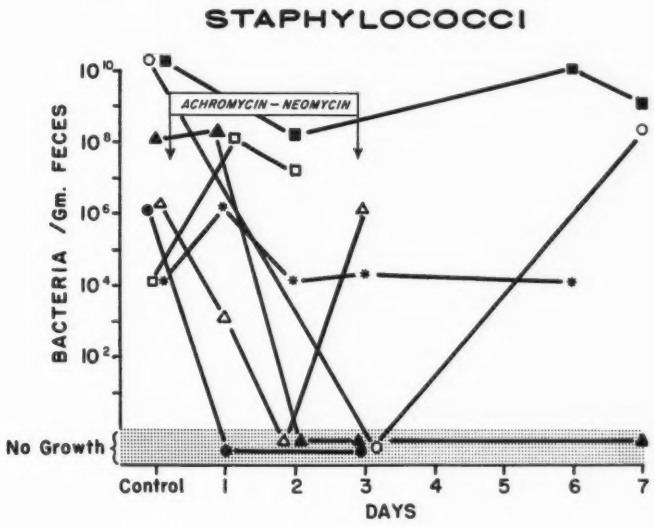


Figure 3.

Subcultures from the anaerobically incubated blood plates were checked at 48 hours and subcultured to thioglycollate broth and blood plates, which were incubated aerobically to eliminate aerobes.

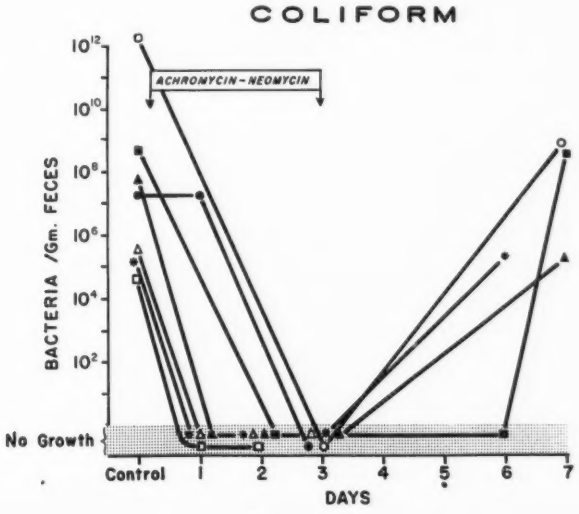
Identification of the various organisms was done according to the following plan:

Coliform: Colony appearance on differential media, biochemical reactions, stain morphology.

Streptococci and Enterococci: Stain morphology in broth and on agar, heat test, catalase test, sodium azide growth.

Bacteroides: Anaerobic growth, stain, and colony morphology.

Clostridia: Stain and colony morphology.



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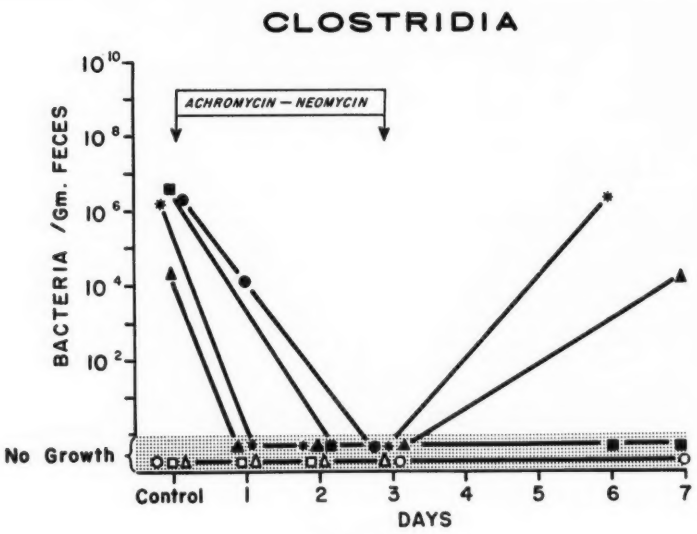


Figure 5.

Staphylococci: Colony morphology, catalase test, agar and broth stain morphology.

Yeasts: Colony and morphology appearance, budding cells.

Any other organisms recovered were identified by similarly accepted techniques.

RESULTS

Seven patients have been studied as described. The reduction in fecal flora can be seen from the graphs.

When specimens were not available, no entry was made on the graphs. The entries

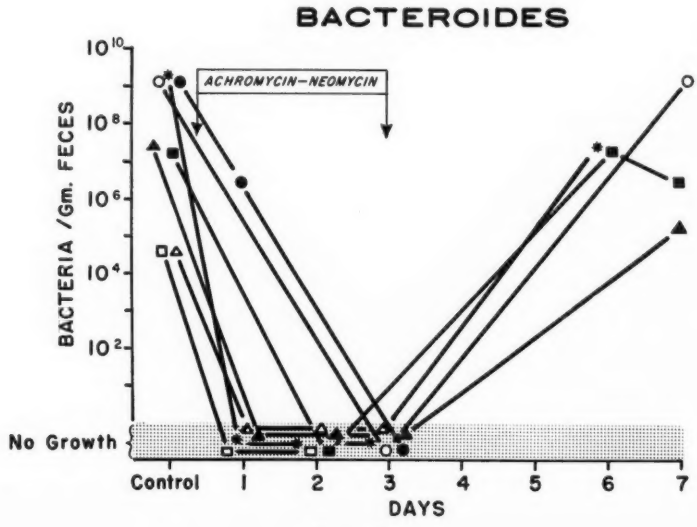


Figure 6.

that show no growth indicate days on which specimens were obtained but growth of that particular organism was not obtained.

Streptococci (Fig. 1) were eliminated from the stool in two patients by the first day, in one additional patient by the second day, and in all but one of the remaining patients by the third day. These organisms did not return to the stool during the period of study in two patients but did in two others.

Enterococci (Fig. 2) were removed from the feces in three patients by the first day and were removed from three more by the third day. The organisms disappeared from by the third day, and in four of the patients they had disappeared by the first day.

Clostridia (Fig. 5) were also completely cleared by the third day. There was no growth of clostridia in three patients by the second day.

Bacteroides (Fig. 6) which are often taken as an index of activity against anaerobic organisms, were removed from the stool by the third day, with five of the patients being cleared by the second day. Bacteroides reappeared in the stool in four patients by the end of the study.

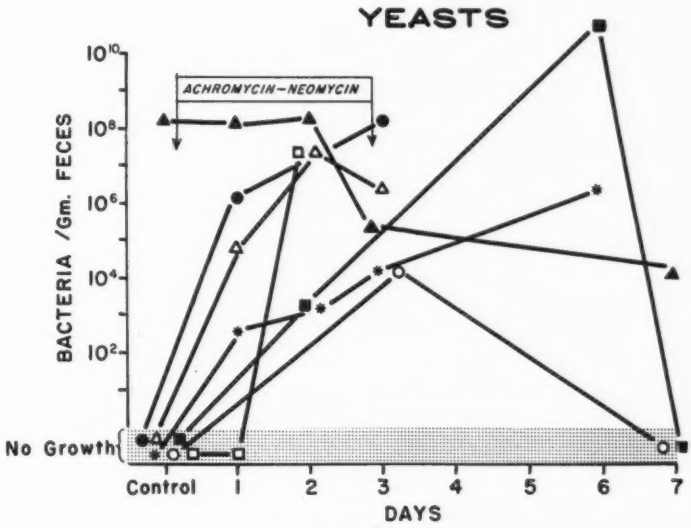


Figure 7.

the seventh patient by the end of the period of study. At this time three patients showed return of the organisms.

Staphylococci (Fig. 3) showed the least response of any organism, but even here the response was not entirely unsatisfactory. Three patients did not respond at all. One responded by the second day but had a return to the original count by the third day. The remaining three patients, representing almost half of the total group, showed complete clearing of the staphylococci by the third day.

Coliform organisms (Fig. 4) were completely cleared from the stool of all patients

Yeasts (Fig. 7) behaved in a manner which was further confirmation of the efficacy of the tetracycline hydrochloride-neomycin mixture. Yeasts were absent from all but one patient at the time of the control specimen. Yeasts began to appear in the stool by the first day and appeared in increasing numbers until the third day, after which they began to decrease. Since it is thought that yeasts are only detected when the normal flora is decreased or else only increase rapidly under these conditions, this is an indirect proof of the control of the bacterial flora of the feces. The rapid disappearance of the

yeasts after the third day is a similar indirect proof of the reappearance of the normal intestinal flora after this time.

Gram-positive rods, found in all patients, were present at the end of therapy in four patients only. They were found in only the control specimen in one patient, in two specimens in five patients, and in five specimens in one patient. Each of the following organisms was found in one or two patients, but none of these organisms were recovered at the end of preparation: anaerobic streptococci, Proteus, Alcaligenes, Pseudomonas, diphtheroids, and paracolon organisms (found three times).

COMMENT

The decrease of the aerobic and anaerobic organisms demonstrated by this study indicates the effectiveness of this combination of agents in decreasing the bacterial flora of the large bowel. The rapid and complete disappearance of so many organisms speaks well for the efficacy of this agent. Likewise, the relatively rapid return to normal indicates that the normal relations between the various organisms in the gastrointestinal tract has not been too seriously interfered with by the short period of bowel therapy. The late appearance and the rapid disappearance of the yeasts suggests that they should not lead to too much trouble.

Comparison with other agents tested thus far shows this combination of agents to be the most effective in decreasing the bacterial flora of the large bowel.

This clinical work has recently been confirmed experimentally in an unexpected manner. A series of eight dogs have been prepared by this same technique. When the colon was divided, it was frequently found to be filled with large masses of fecal material. However, quantitative cultures of this material, by the same techniques used in the clinical series, revealed the fecal contents to be sterile in four and to contain only some of the following nonpathogenic organisms in the other four: Alcaligenes, Pseudomonas, Proteus, and coliform organisms. In view of the extensive flora normally present in the dog's colon, this was an unexpected confirmation of the clinical findings.

SUMMARY AND CONCLUSIONS

Tetracycline hydrochloride (Achromycin)-neomycin combination has been studied for the preoperative preparation of the large bowel. Quantitative stool cultures have been done to evaluate accurately the effects of this combination on the fecal flora.

Three days of therapy rendered the stool almost sterile.

Side-reactions were minimal.

Tetracycline hydrochloride-neomycin in combination with mechanical cleansing is now the routine method of preoperative preparation of the colon on our hospital service.

Fracture of the Odontoid Process

Report of Sixty-Three Cases

EDWIN W. AMYES, M.D., Beverly Hills, Calif.
and
FRANK M. ANDERSON, M.D., Los Angeles

Fracture of the odontoid process has in the past been considered an uncommon lesion with a discouragingly high fatality rate. Osgood and Lund [28] reviewed the subject in 1928 and found the mortality rate to be more than 50% in the 55 cases reported to that date. Since then, however, there has been an increase in the number of recognized odontoid fractures because of the mounting numbers and severity of accidents as well as improvements in x-ray diagnosis. We reviewed the records of 63 previously unreported cases diagnosed since January, 1939. Although other serious injuries often made treatment difficult, death occurred in only five (8%) and only three failed to heal.

Many odontoid fractures as well as other injuries of the upper cervical spine remain overlooked. In conventional roentgenograms of the neck, teeth, mastoid processes, and base of the skull sometimes obscure details of the atlas and axis. Initial films may be poor owing to the inability of the patient to cooperate because of confusion or pain due to cerebral or other injuries. Many such patients admitted in stupor do not complain of neck pain and are hospitalized for treatment of other serious traumatic disorders, with cervical fracture either unsuspected or relegated to a position of secondary importance.

A review of the experiences here (Chart) substantiates the impressions of Jefferson [29] that fractures or dislocations of the upper cervical spine are not rare and emphasizes the need for a careful study of this region in all persons who have sustained trauma to the head or neck.

Opinions of various authors about the treatment and prognosis of odontoid fracture differ considerably and are frequently based on experience with only a few patients. We believe, therefore, that a review of the management and results in our cases may be of interest. The great majority of patients in this series were cared for by the staff of one institution, and similar principles of therapy were applied in all. Forty-two were observed for more than six months after injury, and thirty-two, for a year or more. Seventeen cases treated within the first week were followed for more than two years with no late complications. Osgood and Lund [28] observed in their excellent review that complications and fatalities occur oftenest after the acute effects of injury disappear; hence, a long period of observation is required for accurate determination of morbidity and mortality.

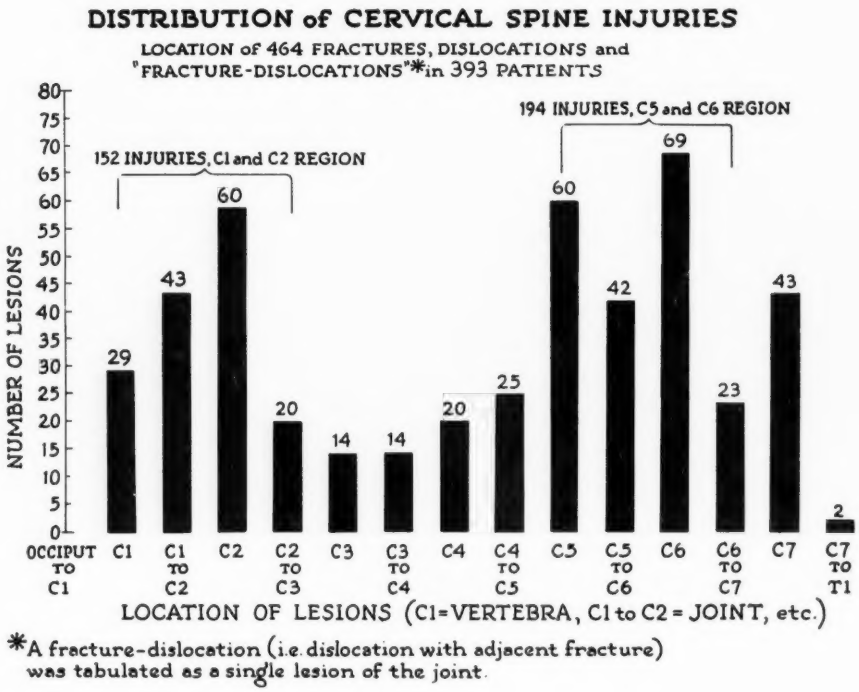
CASE MATERIAL

The relative importance of odontoid fracture as a therapeutic problem in traumatic conditions is indicated by a review of the records of 392 patients with x-ray evidence of fracture or dislocation of the cervical spine admitted to the Neurosurgical Service of the Los Angeles County Hospital between January, 1939, and June, 1954. Many patients had injuries of two or more cervical vertebrae or intervertebral joints, making a total of 464 separate fractures, dislocations, or "fracture-dislocations." * Of 152 with traumatic lesions of the upper cervical spine, 53 had odontoid fractures. Ten additional odontoid fractures are included in our series, four from the Los Angeles County Hospital treated after June, 1954, and six from private hospitals.

Submitted for publication July 11, 1955.

From the Neurosurgical Service of the Los Angeles County Hospital; The Department of Neurosurgery, College of Medical Evangelists, and the Department of Neurosurgery, School of Medicine, University of Southern California.

* "Fracture-dislocation" for statistical reasons was considered a single lesion, although composed of a dislocation with fracture of an adjacent vertebra.



In 34 of the first 53 fractures of the odontoid there was anterior or posterior dislocation of the odontoid fragment and atlas. These are tabulated on the graph as "fracture-dislocations" at the atlantoaxial articulation. In 58 cases a fracture was demonstrated in the x-rays available. In five others early x-ray films were missing, but the roentgenologist described definite fracture and/or dislocation of the odontoid. Several cases were omitted because evidence of fracture was inconclusive.

Diagnosis. — The commonest complaint was painful stiff neck following a head injury. Hospitalization was almost always necessary because of this or associated trauma. Severe pain in the neck or suboccipital region was generally felt immediately after the accident, although on a few occasions the onset was delayed, sometimes as much as 24 hours. Some did not complain because of stupor or other post-traumatic disorders.

Examination revealed marked nuchal rigidity, and most patients objected strenuously to any motion of the head. Soft-tissue swelling in the lateral or posterior neck was occasionally found but was not always localized to the upper neck. The site of maximum tenderness also varied in location.

Although the possibility of odontoid fracture was often considered after the initial examination, the diagnosis was not established in any case until x-rays were obtained. It was often necessary to repeat films before demonstrating a fracture, and planigrams were made if conventional roentgenographic studies were inconclusive.

Neurological Findings.—Five of the fifty-eight patients who survived had sufficient compression of the spinal cord to cause weakness of the extremities; in three, motor involvement was late in onset. In one there was a transient quadriparesis with diminished pain sensation below C-2. Weakness of the left arm persisted for several weeks. In three others there was involvement of only one arm, and in a fifth case both arms were weak but there was no impairment of function of the legs. Other symptoms and findings included numbness and pain in an

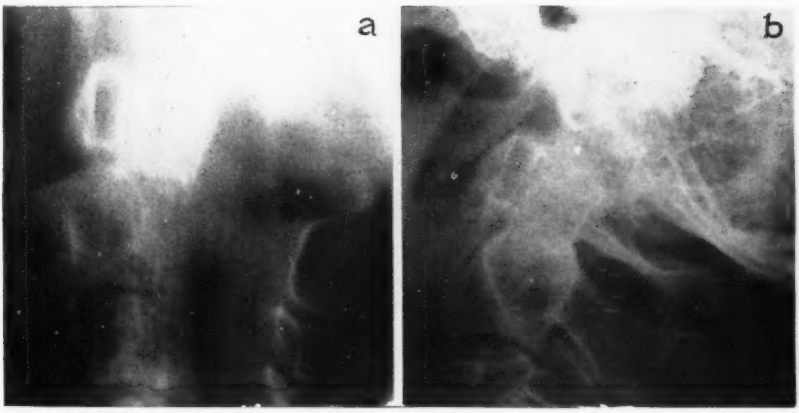


Fig. 1 (Case 32).—(*a*) Planigram shows odontoid fractured and dislocated posteriorly with the atlas. (b) X-ray taken three years later shows satisfactory reduction, although the patient was treated by immobilization without traction.

TABLE 1.—*Results in Sixty-Three Cases of Odontoid Fracture*

	Cases, No.
Diagnosed within first week after injury (57)	
Deaths	5
Remaining under treatment	2
Nonunion (20 mo. later)*	1
Fragments fixed in poor position (7 mo. later)*.	1
Healed or fixed in good position (34 followed more than 6 mo.)	48
Diagnosed 3 or more months after injury (6)	
Treated	
Nonunion (15 mo. later)*	1
Healed	2
Not treated	
Nonunion (2 yr. later)*	1
Fragments fixed in poor position (10 yr. later)*	1
Healed	1
	63
Period of observation† (excluding 5 deaths and 2 under treatment)	Cases
2-3 mo.	7
4-6 mo.	7
7-11 mo.	10
1-2 yr.	14
2-6 yr.	13
8-11 yr.	5
	56

* Time from accident to last x-ray picture of fracture.
† Time from accident to last communication or examination.

upper extremity in one and numbness in the occipital region in two patients.

Treatment and Results (Table 1).—Most patients were kept in bed for a month or more after injury, and immobilization of the head and neck was maintained by means of skeletal traction, cast, or collar. Cervical traction with halter or Crutchfield tongs was used in the treatment of all but a few; tongs were inserted in 38 adults with displacement of the odontoid and/or atlas. Immobilization in a plaster jacket extending from the occiput to the midchest was sometimes the only treatment. It was impossible to use anything more than a Schanz collar in some violent or uncooperative patients. In one such case anatomical reduction resulted and was maintained for at least three years (Fig. 1).

A steel-reinforced leather collar was recommended after traction was discontinued, but there was a great deal of variation in the length of time the neck support was worn. Each patient was instructed to continue wearing his brace until healing was demonstrated by x-ray.

Observation for one year was advised after the dislocation was reduced. X-rays were usually taken each month until the fracture healed. However, as all but a few patients soon felt well, except for persistent stiffness and limitation of motion of the neck, a great many did not return after a few months.

There were a number of difficulties encountered in the use of tongs. One patient developed a decubitus ulcer of the posterior

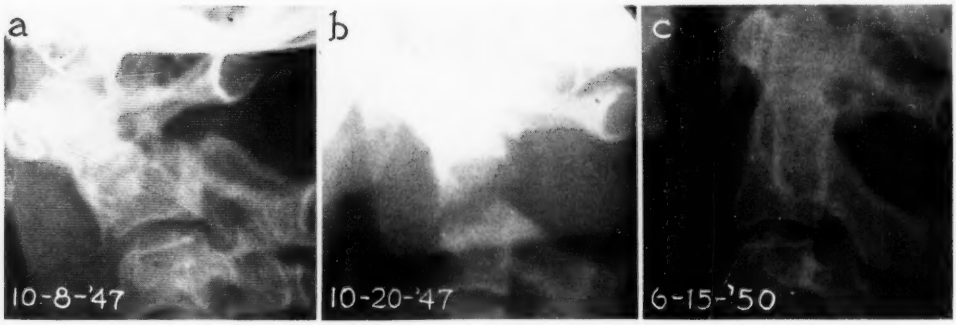


Fig. 2 (Case 25).—(*a*) Fracture extends into body of axis in the anterior portion. Considerable anterior dislocation of odontoid and atlas. (*b*) Thirty pounds of traction on skull tongs reduced the dislocation but distracted the fragments and probably stretched the ligaments, and a decubitus ulcer of the posterior scalp developed. (*c*) Three years later, fracture healed.

scalp, and two developed osteomyelitis of the skull. Strong traction (as much as 30 lb.) in two cases pulled the odontoid fragments farther apart (Fig. 2); one fracture healed when the weight was reduced, but the other was still unstable after 20 months' observation. Three fractures became redislocated while tongs were in place, including the two patients discussed above, who died because of spinal cord compression. Redislocation in a third case, although uncorrected, was of insufficient magnitude to cause any neurological complications. When last examined, seven months after injury, this patient had worn a collar four months and was asymptomatic. It is surprising that there were so few redislocations, as many patients were uncooperative, e. g., one had delirium tremens while in traction and two others removed tongs or weights and got out of bed a few days after injury. Notwithstanding, almost all fractures healed, and, with few exceptions, there were no residual disabling symptoms (Table 1).

Healing.—The rate of healing varied considerably, but roentgen evidence of bony or firm union was usually observed after four to nine months of treatment. The sequence of events in this process is demonstrated in Figure 3. Three fractures, all treated inadequately, remained ununited 15, 20, and 24 months after injury.

Rarely, healing occurred in the absence of immobilization of the head and neck. Apparent fixation of the fragments by fibrous union was achieved in two cases followed 7 months and 10 years, respectively, in which the marked displacement precluded healing by bony union. Bony union seemed probable when the fracture line disappeared in serial x-rays, whether or not callus was observed, but it was often difficult to be certain that the fracture was firmly healed. When there was doubt, planigrams were helpful, e. g., planigrams demonstrated separation of the fragments in two cases (Fig. 4), although callus formed at the periphery of the fracture. Sometimes the fracture line remained visible, but dislocation had not occurred when the patients were last seen, two or more years later, suggesting stabilization by fibrous union.

According to Osgood and Lund,[28] the odontoid fractures of three persons who died later of other causes were found firmly united at autopsy. No details were given concerning the type of union. As we did not have an opportunity to make similar examinations, our conclusions about healing are based on x-ray evidence alone. A study of type and solidarity of union from autopsy material would be an enlightening contribution to our knowledge of these lesions.

Deaths.—The five deaths were due to a variety of causes, and only two were produced by compression of the spinal cord. One occurred in a 23-year-old man (Case 12) who had paralysis of the lower extremi-

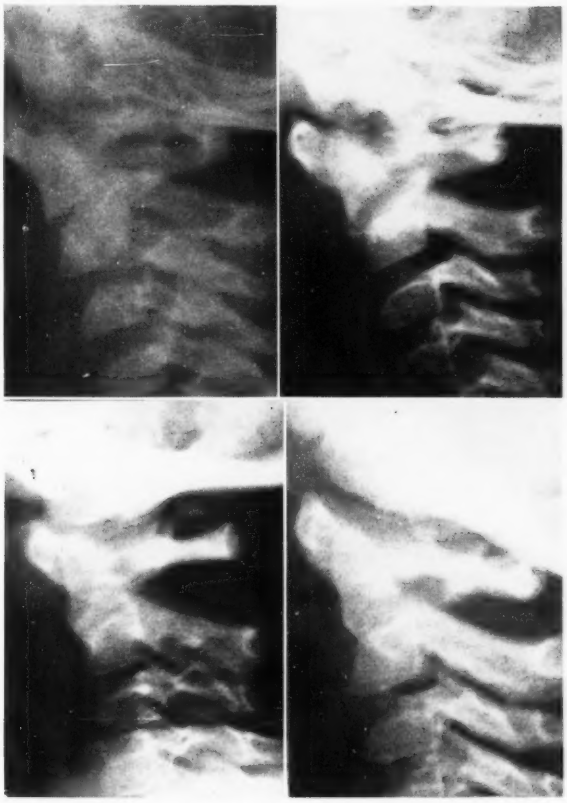


Fig. 3 (Case 63).—Serial x-rays taken during a period of four months demonstrate healing of an odontoid fracture. The anterior dislocation at the atlantoaxial joint was not entirely corrected.

ties, paresis of the upper extremities, and anesthesia below the third thoracic dermatome immediately after injury. He was hyperactive and uncooperative, presumably owing to cerebral contusion. Although Crutchfield tongs were placed within the first 24 hours, the odontoid, probably because of the excessive motion of the patient, became further displaced, with fatal cord compression on the ninth day. The diagnosis was confirmed at autopsy. This fatality might have been prevented if additional support of the cervical spine in hyperextension had been afforded by a plaster jacket.

The second death was that of an 89-year-old man (Case 41) who initially had no signs of neurological dysfunction, although there was marked posterior displacement of the odontoid and atlas (Fig. 5). Tongs were inserted the day after the accident, and the displacement was corrected. The patient became quadriplegic and died after a grand mal seizure eight days after injury.

A third patient (Case 14) developed Staphylococcus meningitis and septicemia five weeks after the accident. X-rays demonstrated posterior displacement of the odontoid plus distention of the prevertebral fascia. A large, fluctuant swelling was palpable on the left lateral aspect of the neck. Although there were never any signs of cord compression and the spinal fluid after treatment became sterile, the patient gradually became more stuporous and died seven weeks after

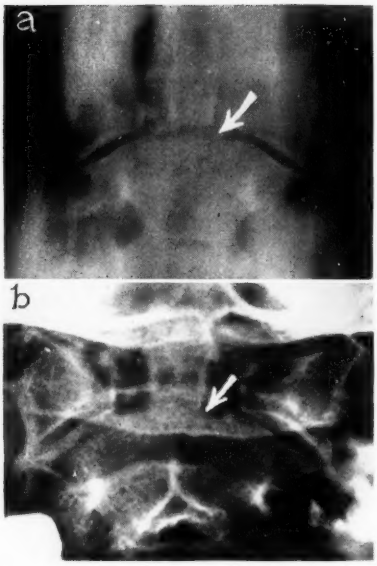


Fig. 4 (Case 61).—(*a*) Anteroposterior planigram shows fracture at base of odontoid (arrow points to line) unhealed 15 months after injury. (*b*) Fracture not seen on plain film. (The lateral view showed a suggestion of a defect.)

injury. Although the autopsy report was not detailed, osteomyelitis might have developed at the fracture site and infection spread to the subarachnoid space. It is also possible that the infectious agent penetrated the mucous membrane of the oropharynx or that a small tear in this membrane compounded the fracture.

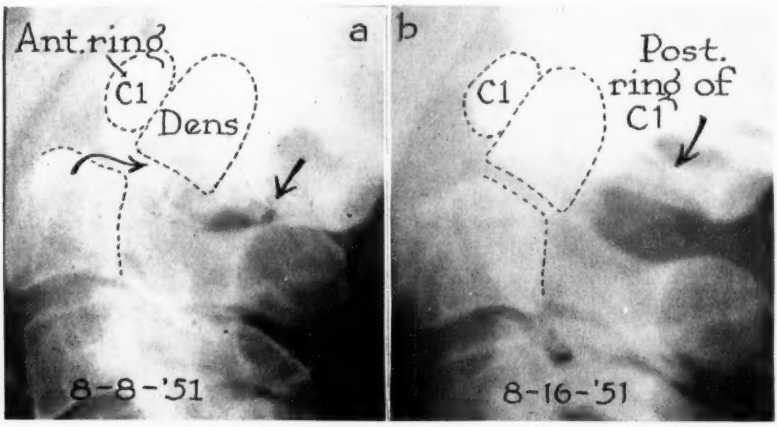
A fourth patient (Case 28) died four days after an accident which caused severe shock, lung contusions, and multiple serious injuries, including fracture of the odontoid with posterior dislocation. Death was preceded by gradual slowing of respirations clinically considered due to medullary compression. However, cord compression was not found at autopsy.

The fifth death (Case 11) was caused by intra-abdominal hemorrhage and shock following rupture of the spleen and diaphragm. Although there was an odontoid fracture with displacement of fragments slightly anterior and to the left, the only neurological defect was spasticity in one leg.

COMMENT

Incidence.—Odontoid fractures are not uncommon after serious injuries. The 13% incidence among cervical fractures and dislocations (53 in 393) encountered at the Los Angeles County Hospital is probably higher than that seen in general practice, owing to the frequency with which patients with major trauma are admitted to this hospital. Crooks and Birkett [9] found 5 frac-

Fig. 5 (Case 41).—(*a*) Initial film. Odontoid (dens) sheared from axis. Fracture in posterior ring of atlas. Marked posterior dislocation. No neurological deficit at this time. (*b*) Patient in traction in tongs and some reduction apparent. Shortly after this film was made, patient had a grand mal seizure, became quadriplegic, and died.



tures of the odontoid among 70 fractures of the cervical spine, an incidence of 7%. There were 3 cases found in 355 cases of fracture of various portions of the vertebral column cited by Osgood and Lund,[28] and there were 2 in 728 cases reported by Böhler.[3] Odontoid fracture complicates about 25% of atlas fractures.[33] However, it is impossible to be certain of the exact incidence of odontoid fracture, for careful examination of the upper cervical spine is not routinely made at autopsy, even when death is due to injury. Death in such cases may be wrongly attributed to other traumatic lesions.

Mortality Rate.—The danger of odontoid fracture and other upper cervical injuries has been exaggerated. Authors who wrote before accurate x-ray diagnosis was available believed the prognosis grave or hopeless.[34] Uncomplicated cases were overlooked because physical diagnosis was impossible without the ominous signs of atlantoaxial dislocation or neurological deficit. A change in outlook is seen in the 55 cases reported to 1928,[28] a period spanning improvement in x-ray technique. Of the first 40 cases, 14 alone survived, but only 2 of the last 14 died. In 40 cases published since 1928 there were 6 deaths (15%), but because most were reported as single cases it is likely that the unusual and fatal were emphasized.† The mortality rate in our 63 cases was 8%, even though deaths due to associated injuries were included.

Anatomical Considerations in Upper Cervical Injuries.—The odontoid process acts as a pivot about which the occiput and atlas rotate and is held forward against the anterior arch of the atlas by the thick transverse ligament which spans the ring of the atlas and bears on the posterior surface of the base of the odontoid.[37] Unless this ligament is weakened by disease, e. g., rheumatic fever, adjacent cervical infection, etc.,‡ it does not stretch and is almost always stronger than the odontoid. The atlantoaxial joint is potentially unstable and will allow gliding motions in an anteroposterior direction as well as an abnormal amount of rotary movement if the odontoid is fractured or the ligament lax.[36] A small amount of lateral motion at this joint is often seen in normal persons,§ but marked lateral displacement is usually associated with fracture of the atlas or axis.[50]

The upper cervical spine, of which the odontoid is one of the more important components, functions as a unit. It may be considered to extend from the junction of the second and third cervical vertebra to the foramen magnum and lies immediately behind the pharynx. The construction allows free motion of the head and protects the lower medulla, upper two segments of the cervical cord, and anterior spinal artery. Considerable displacement is possible without cord compression because the cord is about 10 mm. in diameter, whereas the canal in this region measures on an average 30 mm. transversely and 25 mm. sagittally.[35] The vertebral arteries are rarely injured where they pass through the transverse processes of the atlas and axis. Branches of the first three cervical nerves may be damaged as they emerge between the vertebrae or the atlas and occiput; the greater occipital nerve is particularly exposed where it passes posteriorly through the atlantoaxial membrane.[28] The glossopharyngeal, palatal, and chorda tympani nerves or the adjacent superior constrictor muscles of the pharynx are close enough to be contused or stretched by atlantoaxial dislocation.[25] Occlusion of the internal carotid artery is possible if the atlas be sufficiently rotated.[62]

Developmental Anomalies Important in Injury.—The stability of the upper cervical region may be impaired or the neural canal narrowed by developmental abnormalities. When the atlas is firmly united with the occiput ("occipitalization of the atlas"),[39] or in cases of basilar impression,[40] the odontoid moves upward in the spinal canal and the cord may be compressed after a minor injury. Although ossification of the odontoid

† References 1 to 27; Scarff, in Brock.[14]

‡ References 38 and 46.

§ References 49 and 50.

is complex and proceeds from three centers, anomalous development is uncommon. The odontoid rarely may be completely absent, or the tip or base alone may form, rendering the atlantoaxial joint unstable.‖ The odontoid is joined to the body of the axis by cartilage, which usually ossifies at the periphery, although a small disc remains at the center until old age.[20] However, in almost 25% of persons between 30 and 50 there is incomplete bony union between the odontoid and the body of the axis,[41] which may predispose to fracture or poor healing.

Mechanisms of Injury. — It was early thought that strength of the atlantoaxial joint depended to a considerable degree on the cervical muscles and that muscular relaxation in sleep or unconsciousness increased the risk of dislocation and fracture.[36] This view is no longer held, although spasm of injured muscles probably aids in immobilizing the neck. In support of this theory is the fact that further dislocation and cord compression most commonly occur after the acute effects of injury have subsided. The articular ligaments are believed to offer no support, but their gradual stretching would explain progressive dislocation months or years after odontoid fracture. The matter needs additional study.

Mechanisms of injury of the atlas and axis were studied by Wüsthoff,¶ Jefferson, and others,# who found that fracture and dislocation were almost always the result of force applied to the head and not to the neck. The odontoid was concluded to be most fragile at its base, stronger than the atlas, and weaker than the transverse ligament. Force applied to the head from the rear fractures the odontoid, which is sheared off by the transverse ligament and dislocated forward. Blows on the forehead with hyperextension produce posterior dislocation and fracture of the odontoid or crush the slender posterior arch of the atlas between the occiput and axis.

‖ References 37, 41, 42, 43, and 62.

¶ Wüsthoff, R., in Osgood and Lund.[28]

References 31 to 33.

In our series some idea of the site of application of force was obtained from the location of scalp lacerations or bruises, but there was no correlation of an external lesion with a specific type of cervical injury. Fracture of the odontoid was due in one patient to a blow on the back of the neck and in two cases to injury at the vertex. It is possible that the latter two patients were flexing the head slightly at the moment of impact, but the major force was applied in the vertical axis. The most significant finding in our patients was that the force of injury was often great, for 38 of the 63 persons with odontoid fracture sustained, in addition to either cerebral concussion or contusion, other fractures or major injuries, with shock. A vehicular accident was the most frequent means of injury (Table 2).

TABLE 2.—*Means of Injury*

	Cases, No.
Motor vehicle	36
Falls (some minor)	13
Blow to head	5
Unknown	5
Miscellaneous	2
Chiropractic manipulation	1
Blow to neck	1
Total	63

Radiographic Studies. — Minimal x-ray studies of the odontoid and body of the axis should include views through the open mouth as well as from the lateral aspect. Clear delineation of all the bony detail, especially the junction of the odontoid and body of the axis, is absolutely essential. Occasionally the fracture may not be evident roentgenographically until a degree of bony absorption occurs.[30] Before the collar is discarded at the conclusion of treatment, lateral films taken with the head extended and flexed will aid in determining stability at the atlantoaxial joint.

Details of the odontoid process may be demonstrated by use of dental film placed against the anesthetised posterior pharynx.[51] If plain films are inadequate and equipment is available, planigrams will be found to be

of great help. Their routine use will prevent error, e. g., by disclosing breaks in the ring of the atlas and precisely demonstrating the position of the odontoid and relationships at the atlantoaxial joint. Whenever persistent callus is formed at the fracture site, a planigram should be made before the patient is discharged, as nonunion may be obscured by the overgrowth of osseous tissue. Planigrams to be of any value must be of excellent technical quality.

TABLE 3.—*Complications of Odontoid Fracture*

I.	Immediate
	A. Dislocation of atlantoaxial joint and odontoid; anterior, posterior, rotary, or lateral
	B. Compression of spinal cord with concussion, contusion, or necrosis oftenest of anterior surface; region at pyramidal decussation susceptible and motor fibers to the arms or legs may be selectively involved
	C. Compression of anterior spinal artery or of one or both vertebral arteries
	D. Hemorrhage
	1. Within spinal canal: extradural, subdural, or subarachnoid
	2. Outside canal with distention of the prevertebral fascia or tearing of adjacent muscles; causes dysphagia or dyspnea; bleeding primarily from vertebral arteries and veins
	E. Contusion or tearing of greater occipital, chorda tympani, glossopharyngeal, or palatal nerves
	F. Contusion or tearing of muscles, e. g., constrictor muscles of pharynx
II.	Delayed
	A. Dislocation of atlantoaxial joint due to failure of fracture to heal and sometimes associated with weakening of transverse or alar ligaments; late dislocations may be recurrent, progressive, or sudden and fatal
	B. Compression of spinal cord; chronic and incomplete, recurrent, progressive
	1. Atrophy of crossed pyramidal tracts
	2. Local necrosis and cavity formation
	C. Excessive callus formation at fracture site
	D. Osteomyelitis; meningitis
	E. Chronic adhesive arachnoiditis
	F. Avascular necrosis of odontoid

Marked displacement of the odontoid and axis are sometimes seen in x-ray films in the absence of signs of spinal cord compression (Fig. 5*a*), but the converse is also true. In the former case the cord may escape damage by being lateral to the displaced odontoid. Rarely, temporary displacement of fragments will produce cord contusion, although the fragments be in apparent alignment when films are made (Case 61).

Complications (Table 3). — Incomplete cord injury is the commonest early complication and was found 5 times in our 63 cases and in 10 of 40 reported since 1928.* The usual features (Grogono [37]) are weakness, exaggerated reflexes with pathological toe signs, impairment of pain and temperature sense, hyperesthesia or numbness in the occipital area, and paresthesia or hyperesthesia of the hands and fingers. Damage to the spinal cord is usually severest anteriorly; this localization may be due to local trauma by the odontoid or, as some believe, the result of compression of the anterior spinal artery. Injury to the pyramidal decussation which lies behind the odontoid produces a variety of disorders, such as isolated weakness of one or both arms,[53] triplegia, paraplegia, or hemiplegia.† Complex disturbances, visual difficulty, loss of consciousness, etc., may follow compression of the vertebral artery [41] as a result of instability of the atlantooccipital joint. Hemorrhage from this vessel occasionally distends the prevertebral fascia, causing dysphagia.[45] This symptom plus alteration in phonation and taste may also follow muscular injury or damage to the glossopharyngeal, palatal, or chorda tympani nerves.[25] Numbness in the occipital region suggests compression or tearing of the lesser or greater occipital nerves.‡ Anterior displacement of the posterior arch of the atlas may result in spinal fluid block.[8]

The late complications that are known to follow odontoid fracture make accurate prognosis difficult, even in favorable cases. However, delayed effects were not observed in any of our cases when the fracture was reduced soon after injury and maintained in position for six months. Those cases in which fracture cannot be demonstrated by planigraphy certainly should be considered safely healed.

Redislocation, often gradual, is the commonest late complication, but excessive mobility at the atlantoaxial joint, myelitis, osteomyelitis, arachnoiditis, excessive callus

* References 1 to 27; Scarff, in Brock.[14]

† References 17, 28, 31, and 32.

‡ References 31 and 32.

formation, and avascular necrosis of bone at the fracture site have been reported.§

The interval of time between the accident and complications varies greatly. One of the longest periods between fracture and death from cord compression is that cited by Elliott and Sachs,[52] whose patient died 32 years after injury. Schwarz and Wigton[23] reviewed the problem of late complications and cited two examples, with intervals of 5 and 18 years between fracture and spinal cord compression. In a case described by Jefferson,[31] 15 months elapsed between fracture and death from osteomyelitis of the atlas and axis. In the case of Chavany[6] cord compression due to excessive callus formation occurred 10 years after injury.

Death from compression of the spinal cord following odontoid fracture can be an immediate effect of injury but usually occurs several days or more after the accident. Marked soft-tissue swelling in the neck appearing a few hours after fracture may require tracheotomy.

There were 29 fatal cases in the series of Osgood and Lund, but only 6 patients died as an immediate result of injury.[28] The late onset of many complications was emphasized by these authors, who believed that an incident trivial in character, such as sneezing or sudden motion of the head, often precipitated fatal paralysis. However, in our two fatalities due to cord compression death was preceded by violent activity. Although great care must be exercised in handling patients with odontoid fracture, the complications are not so imminent as to make operative reduction or fusion desirable before simple immobilization or traction is tried.

Autopsy Findings. — Postmortem studies confirm the clinical impression that the spinal cord is usually most severely damaged in its anterior portion. However, fatal concussion of the spinal cord without hemorrhage or evidence of compression has been reported. Autopsy findings have varied from absence of gross change to extensive compression or hemorrhage into the cord.[31] Chronic compression of the spinal cord may produce indentation on the anterior surface[60] and degeneration of the crossed pyramidal tracts.‖ Atlantoaxial dislocation, which has a similar effect, may give rise to local necrosis of the cord[56] or contusion of the ventral surface and cavity formation.[61]

Treatment. — Emergency treatment of odontoid fracture and other atlantoaxial lesions requires fixation of the head and neck in neutral position and prompt hospitalization. Dislocation must then be reduced by traction and the fracture site immobilized to permit healing and prevent additional spinal cord damage. Respiratory embarrassment may necessitate tracheotomy, care in a respirator, or both. Infection at the fracture site should be combated by antibiotics.

In the presence of more than slight dislocation traction in tongs is generally indicated, but for a child or a patient with a laceration of the scalp a head halter may be desirable. Five to seven pounds of pull in tongs are usually enough to reduce dislocation and thereafter should be maintained at least two weeks before the patient is placed in a collar. More than 4 lb. of pull in a halter is usually not tolerated for more than a few days because of resultant soreness in soft tissues over the chin or reaction in the temporomandibular joint. Four to six weeks of bed rest in all cases, including those without dislocation, is desirable. We are in general accord with the recommendations of Grogono[37] that in the case of older persons, especially where disability is minor, a plaster collar alone may be sufficient, but skeletal traction should be instituted in the presence of severe displacement. Watson-Jones[38] also believed results of treatment with a cast might be excellent and advised operative fusion only if the closed treatment was unsuccessful.

A few authors have given specific advice as to the duration of immobilization. Hambly[11] believed bony union following fracture of the odontoid might occur in three months and advised that a collar be worn for an

§ References 6, 10, 13, 23, and 24.

‖ References 47 and 52.

additional month. Osgood and Lund [28] recommended immobilization in plaster for three months and a Thomas collar for three more.

In our practice a plaster jacket or steel-reinforced leather collar that extends from the top of the occiput to the midchest is worn until x-rays demonstrate healing of the fracture. Much lighter plastic braces are being developed, and these may prove equally satisfactory. Immobilization for at least six months is advisable, and the patient should be kept under observation for a year after the fracture is reduced. The progress of healing and the position of the fragments is checked by monthly x-rays. Immobilization by jacket or collar alone, even in the presence of dislocation, offers less risk than skeletal traction if the patient is uncooperative.

It is generally agreed that operative fusion is at times indicated. It would seem best to reserve such surgery for those cases with instability at the fracture site following a trial of traction and immobilization. We advise treatment in a collar for as long as nine months after the fragments are approximated before deciding that the fracture will not heal. If redislocation takes place or serious neurological dysfunction appears during this time, orthopedic consultation is indicated and surgery should be considered. Treatment must, however, be individualized according to the severity of the injury and the complications encountered, e. g., marked instability at the atlantoaxial joint observed during the first few weeks may make immobilization by traction and plaster jacket alone unusually hazardous.

Medical writers differ regarding indications for operative fusion in cases of odontoid fracture with atlantoaxial dislocation. Grogono [37] advised reduction and fusion of the atlas and axis with recurrent dislocation or signs of spinal cord compression. Kahn and Yglesias [16] considered fusion indicated when the dislocation was progressive, whether or not signs of cord compression developed. Albee [58] advised fusion if signs of cord compression increased. Crutchfield,[57] however, recommended fusion in all dislocations of the atlas and axis, for he believed they almost invariably recurred.

Operative fusion of the atlantoaxial joint was performed but once in our series. Surgery was done elsewhere after a second neck injury in a case whose initial fracture healed after traction and immobilization. Unfortunately, the details of the later accident and indications for surgery could not be ascertained. Fusion was indicated in the three cases whose fractures did not heal,¶ but these patients are not under our care.

SUMMARY

Sixty-three cases of odontoid fracture are presented, and the diagnosis and treatment are discussed. This fracture is concluded to be a not uncommon lesion of considerable clinical importance.

Marked nuchal rigidity and severe pain in the neck and suboccipital region were prominent features. Neurological involvement, noted in 11 of our cases, varied from occipital hypalgesia to fatal paralysis. Incomplete compression of the anterior spinal cord near the pyramids produced various extremity paralyses, most commonly of the arms, as well as alterations of pain and temperature sense.

Diagnosis was established by x-ray, for no clinical findings were specific for this fracture. The value of planigrams was demonstrated.

Treatment generally included bed rest; traction, preferably in Crutchfield tongs, and immobilization of the head and neck in a steel-reinforced leather collar. Operative fusion of the upper two cervical vertebrae was performed in one case.

All but three fractures healed or became immobilized after four to nine months of treatment. The three failures were the result of inadequate or improper treatment, and operative fusion was indicated.

Five patients died, two following spinal cord compression more than a week after the accident, two of associated injuries, and one of complications of meningitis.

¶ Taylor, G. M.: Personal communication to the authors.

TABLE 4.—*Summary of 63 Cases of Odontoid Fracture*

Case	Sex	Age, Yr.	Means of Injury	X-Ray Findings (Odontoid Fractured Only at Base)	Neurological Disorders Due to Odontoid Fracture	Other Injuries	Treatment and Course	Follow-Up‡	Comment
1	M	32	Blackjacked at nape of neck	C-1 * forward on C-2 † 13 mm.; odontoid displaced anteriorly ½ its diameter	None	None	Traction in tongs 3 mo.; leather collar 3 mo. +	Good 1 yr.	No neck pain until neck swelling started the 2d day; delirium tremens made treatment difficult
2	F	27	Auto vs. pedestrian	Slight displacement of odontoid	Anesthesia below L-1 (considered hysterical)	None	Traction in halter 5 days; leather collar 6 mo. +	Good 11 yr.	Fracture line indistinct 3 mo. after injury
3	M	66	Run over in driveway	Odontoid displaced forward	None	In shock with multiple injuries	Traction in tongs 1 mo.; leather collar 1 yr.	Good 4½ yr.	.....
4	M	45	Auto vs. pedestrian	Fracture extended into body of C-2	None	Concussion	Traction in halter 3 wk.; probably wore a leather collar	Good 8 yr.	.....
5	F	64	Tripped on curb and fell	Odontoid displaced slightly forward and to right	None	None	Plaster jacket	Good 3 yr.	.....
6	M	73	Unknown	Odontoid displaced slightly to right and anteriorly	Occipital headaches	None	Traction in tongs 6 wk.; probably wore a collar	Good 6 yr.	Fracture almost healed in 4 mo.
7	M	59	Auto vs. auto	Odontoid displaced 3 mm. anteriorly and slightly laterally	None	Concussion; multiple injuries	Traction in tongs 5 wk.; leather collar 10 mo.	Good 9 yr.	.....
8	M	57	Auto vs. pedestrian	Fracture extended into body of C-2	None	Cerebral concussion, lacerations and abrasions	Head halter and leather collar, tongs, and Minerva jacket	Good 3 mo.	.....
9	F	21	Auto over cliff	Good position	Transient quadriplegia; slow return function one arm	None	Traction in halter 7 wk. leather collar 20 mo. +	Good almost 2 yr.	.....
10	M	52	Auto vs. ravine	Odontoid displaced slightly to left	Weakness of left leg believed due to fracture of L-4	Concussion and multiple injuries	Traction in halter 1 mo.; leather collar 4 mo.	Good 8 mo.	Fracture line almost gone at 5 mo. and obliterated in 8 mo.
11	M	62	Auto vs. milk truck	Odontoid displaced slightly anteriorly and to left	Spasticity of one leg	Ruptured spleen and diaphragm; severe shock	Immobilization; death from other injuries	Died 3d day	Odontoid fracture did not contribute to death
12	M	23	Thrown from auto	Odontoid displaced anteriorly its diameter	Weak arms; flaccid paralyzed legs; anesthesia to upper thorax	Head injury; coma	Traction in tongs from day of admission; patient originally improved; uncooperative; grew worse and died	Died 9th day	Autopsy: hemorrhage into spinal canal and base of brain; spinal cord compressed
13	M	22	Fell downstairs	Odontoid displaced anteriorly 4 mm.	None	Reportedly unconscious for 48 hr. after fall	Traction in halter after 1st injury; after 2d injury, 9 yr. later, upper cervical vertebrae wired	Good 11 yr.	Patient psychopathic, inconsistent in treatment; two or more neck injuries; severe pain; surgery elsewhere
14	M	70	Dumbwaiter fell on head	Odontoid displaced posteriorly	Fatal Staphylococcus meningitis	None	Treatment of meningitis only	Death probably from meningitis after 7 wk.	Neck swollen and tender; whether fracture precipitated meningitis is problematical; autopsy inconclusive
15	M	36	Auto vs. pedestrian	Odontoid displaced few mm. anteriorly	Late onset weakness right arm; relieved after traction in tongs	Coma, shock, and multiple injuries	Undiagnosed for 3 mo.; traction in tongs 2 wk.; leather collar	Good 6 yr.	Weakness of arm first ascribed to head injury since he had few complaints referrable to his neck

16	M	61	Auto vs. pedestrian	Odontoid displaced to right	None	Multiple, including lacerations of face	Traction in tongs 3 wk.; leather collar 2 mo. +	Followed 4 mo.	.....
17	F	49	Probably injured 1 yr. before admission	Odontoid displaced	None	None	Healed without treatment	Good 1 yr.	Evaluation difficult; fracture found during routine investigation of multiple complaints
18	M	63	Auto vs. auto; thrown to one side	C-1 displaced posteriorly 5 mm. on C-2	None	None	Traction in tongs 5 wk.; leather collar 1 yr.	Good 1 yr.	.....
19	F	70	Fell on floor	Odontoid displaced 1 mm. to left	None	None	Traction in tongs 2 mo.; collar worn inconstantly	Good 8 mo.	Patient senile and did not cooperate
20	M	76	Fell at work	Good position; fracture of atlas	None	Laceration left forehead	Traction in halter 2 days; traction in tongs 1 mo.; leather collar 4½ mo. +	Died 3 yr. later, age 79 (cause unknown)	.....
21	M	21	Auto accident	Odontoid displaced slightly to left	None	Laceration left forehead	Traction in halter 3 days; traction in tongs 3½ wk.; leather collar 3 wk.	Followed 6 wk.	.....
22	M	26	Motorcycle vs. auto	Odontoid displaced slightly to right	None	Concussion; scalp laceration	Traction in tongs 1 mo. +; probably wore a collar	Good 10 mo.	Patient removed his tongs and they had to be reinserted; fracture line obliterated in 6 mo.
23	F	19	Auto accident	Odontoid displaced 3 mm. anteriorly	None	Concussion; probable middle fossa fracture	Traction in tongs 2 mo.; leather collar 1 yr. +	Good 2 yr.	Fracture line disappeared in 4 mo.
24	M	85	Auto vs. pedestrian	C-1 displaced to left; possible fracture of lateral mass of C-1	Transient shooting pains and numbness right upper extremity	Multiple and serious, including hemopneumothorax	Traction in tongs 4 wk.; Schanz collar and leather collar 6 wk. +	Good 4 mo.	.....
25	F	30	Auto accident	Odontoid displaced 6 mm. anteriorly; marked swelling and narrowing of pharynx	None	Cerebral contusion; shock with multiple injuries	Excessive traction in tongs caused 1 cm. separation of fragments and decubitus ulcer posterior ½ of scalp	Good after traction reduced to 5 lb.; good 2⅔ yr.	Good result; no fraction line evident 1 yr. after injury
26	M	55	Fell downstairs	C-1 displaced on C-2 3 mm. to left	None	None	Traction in tongs 1 mo.; wore Minerva jacket and leather collar	Good 5 yr.	.....
27	M	20	Auto vs. bicycle	Good position	None	Multiple injuries	Traction in halter; probably wore a collar	Good 17 mo.	Fracture line almost gone in 10 mo.; healed in 15 mo.
28	F	35	Auto accident	Transverse fracture with 2 mm. posterior displacement of odontoid	None (disorders probably due to head injury)	Cerebral contusion; multiple injuries	Tongs	Died 4th day	.....
29	M	16	Auto vs. curb	Irregular fracture	None	None	Traction in tongs 1 mo.; Minerva jacket and leather collar	Good 19 mo.	Fracture line almost gone in 3 mo. and obliterated in 5 mo.
30	M	39	Attacked and beaten	Odontoid displaced anteriorly ½ its diameter; bilateral fracture posterior arch C-1	None	Concussion; scalp laceration at vertex	Traction in tongs 1 mo.; Minerva jacket and leather collar 1½ yr.; local osteomyelitis of skull at tong insertion site	Good 1½ yr.; skull osteomyelitis healed	Fracture line indistinct at 7 mo.—absent on lateral but not on anteroposterior views at 1 yr.
31	F	77	Injury 10 yr. before, probably due to manipulation	Odontoid displaced posteriorly 1 cm.	None	None	None	Fragments displaced but fixed after 10 yr.	Healed without treatment
32	F	66	Fell downstairs	Odontoid displaced 5 mm. posteriorly	None	None	Plaster collar and later leather collar for total of 2 yr.	Good 3 yr.	Patient temporarily psychotic and restrained; forced feeding necessary

TABLE 4.—*Summary of 63 Cases of Odontoid Fracture (Continued)*

Case	Sex	Age, Yr.	Means of Injury	X-Ray Findings (Odontoid Fractured Only at Base)	Neurological Disorders Due to Odontoid Fracture	Other Injuries	Treatment and Course	Follow-Up†	Comment
33	F	64	Auto vs. pedestrian	Odontoid displaced about 3 mm.	None	Concussion; scalp hematoma	Traction in tongs 2 mo.; leather collar	Good 6 yr.	Tong insertion delayed by scalp hematoma; 4½ mo. after injury callus seen, although displacement persisted
34	M	54	Fell while drinking and struck head	Bilateral displacement of lateral mass of atlas on axis	None	None	Refused tongs; placed in Minerva jacket	Now under treatment	.....
35	M	20	Unknown	Odontoid displaced anteriorly ⅓ its diameter	None	Concussion	Traction in tongs 2 mo. +; leather collar worn inconstantly	Good 4 mo.	Traction resulted in gradual improvement in position
36	M	74	Auto vs. pedestrian	Odontoid displaced 4 mm. posteriorly	None	None	Traction in tongs 2 mo. +; leather collar 3 mo.	Good 5 mo.	Patient disengaged traction in p. m. and walked about; reduction of displacement difficult
37	M	30	Fell from bed; other injury probably	Odontoid displaced to left	None	Multiple injuries; contusion right forehead	Traction in tongs 6 wk.; leather collar 2 wk. +	Followed 2 mo.	.....
38	M	15	Jumped off train and hit a lamp post	Odontoid displaced anteriorly	None	Concussion	Traction in tongs about 8 mo.; faulty traction led to separation and angulation	Needed collar 20 mo. or more after injury	No evidence of healing after 8 mo.; tongs reapplied and reduction achieved but not certain final result good
39	M	48	Beaten and robbed	Odontoid displaced anteriorly 1 cm.	Weak arms, legs spared; hypalgesia or anesthesia to C-2	Head injury; confused at least 1 wk.	Traction in tongs 3½ mo.; leather collar 4 mo. +	Fixed in forward position 7 mo.	Isolated weakness of arms; time of onset unknown, for he wandered about confused for a week prior to admission
40	F	78	Auto vs. pedestrian	Odontoid displaced posteriorly; fracture posterior arch of atlas	None at first; late weakness right arm	Concussion, lethargy, large scalp hematoma	Traction in tongs 2 mo.; leather collar 3 mo. +; weakness of arm disappeared after traction	Good 9 mo.	Fracture line visible 7 mo. after injury, but position good
41	M	89	Unknown	Odontoid displaced posteriorly 1 cm.	None on admission; late quadriplegia	Laceration right frontal scalp	Traction in tongs from admission until death; dislocation reduced but recurred with quadriplegia after convulsion	Died 8th day	Convulsion occurred without warning
42	F	15	Auto accident	Odontoid displaced anteriorly	None	Concussion; laceration of scalp at vertex	Traction in tongs 9 wk.; leather collar 18 mo.	Good 20 mo.	Some healing noted 3 mo. after injury
43	M	71	Fell while intoxicated	Slight posterior displacement C-1 on C-2	Numbness in occipital region	None	Traction in tongs 2 mo.; infection in wounds about tongs; soon healed	Followed 3 mo.	.....
44	F	69	Fell down 12 steps and struck head	Odontoid displaced posteriorly	None	Hematoma of frontal scalp	Traction in tongs 2½ mo.; leather collar 1 yr. +	Good almost 3 yr.	.....
45	F	62	Auto vs. lamp post	Odontoid displaced 4 mm. anteriorly	None	Concussion	Minerva jacket and leather collar	Followed 2 mo.	Patient refused traction; uncooperative
46	M	36	Truck vs. truck	Odontoid displaced to right	None	Concussion; multiple serious injuries	Traction in tongs 5 wk.; leather collar	Probably good 13 mo. (no details)	.....
47	M	40	Auto accident	Odontoid displaced moderately anteriorly	None	Concussion; multiple injuries about face and neck	Traction in tongs 6 wk.; leather collar 6 wk. +	Good 2 yr.	.....

						face and neck			
48	M	52	Struck on back of head	Odontoid displaced anteriorly ¾ of vertebral body	Numbness in occipital region	Concussion	Traction in tongs 6 wk.; leather collar 3 mo. +; infection in wounds about tongs	Good 4½ mo.; displacement reduced	Some evidence of healing at 3 mo.
49	F	9	Auto accident	Fracture arch C-1 and C-7	None	Concussion; fracture both femurs	Placed in body cast and later in plaster jacket	Good 7½ mo.	.....
50	F	52	Fainted and struck head	Odontoid displaced anteriorly	None	None	Traction in tongs and halter; leather collar	Good 2 yr.	.....
51	M	31	Drunk and fell or thrown out of 3d story window	Odontoid fractured just below base with slight anterior displacement	None	Colles fracture; cerebral concussion, scalp laceration	Leather collar	Good 4 mo.	.....
52	M	39	Auto vs. train	Good position	None	Concussion; scalp lacerations; multiple injuries	Traction in tongs 2½ mo.; leather collar 2½ mo. +	Good 10 mo.	.....
53	M	64	Struck on top of head by crate of cabbage	Odontoid displaced slightly to left	None	None	Traction in tongs 5 wk.; leather collar 6 mo. +	Good 7 mo.	.....
54	M	30	Auto vs. truck	Odontoid displaced anteriorly	None	Concussion	Tongs 6 wk. +	Followed 2 mo.	.....
55	M	28	Auto accident	Good position	None	Cerebral contusion; laceration in neck	Traction in halter 10 days; plaster collar to date (10/20/54)	Good 5 mo.	Undiagnosed for 1 wk. because patient was confused; tracheotomy, breathing being impaired by swelling of neck
56	F	83	Fell and struck head after cerebral thrombosis	Anterior displacement of atlas	None	Fracture left arm	Minerva jacket	Now under treatment	.....
57	M	64	Auto accident	Odontoid displaced slightly posteriorly	None	Cerebral contusion and multiple severe injuries	Head halter with 5 lb. traction; Thomas collar	Good 2 mo.	.....
58 §	M	54	Unknown	Good position	None	None	Not treated until 5 mo. after injury; then wore leather collar 6½ mo.	Good 11 mo.	Although fragments not displaced, no healing until neck immobilized
59 ‖	M	45	Auto vs. auto	Good position	Bilateral Babinski signs possibly due to concussion	Concussion	Plaster collar and brace 8 mo.	Good 8 mo.	.....
60 ¶	F	17	Auto accident	Odontoid displaced anteriorly	None	None	Traction in halter 5 wk.; leather collar 5 mo. +	Good 2 yr.	Planigrams 7 mo. after injury showed bony union notwithstanding 2 mm. anterior displacement
61 §	M	26	Hit by trailer	Good position	Intermittent weakness one arm; onset 9 mo. after injury	Concussion	Leather collar worn inconstantly 5 mo. (5th to 10th mo. after injury)	Callus formation increased but unhealed after 15 mo.	Inadequate and late immobilization resulted in nonunion; presumably recurrent dislocations caused late neurological deficit
62 §	M	6	Auto vs. bicycle	Good position	None	Cerebral contusion; thoracic injury with paraplegia	None	Unhealed after 2 yr.	Callus formed, but nonunion demonstrated on planigrams
63 ≠	F	3	Injured playing leapfrog	Odontoid displaced anteriorly	None	None	Traction in head halter and cervical brace 4 mo.	Good 3 yr.	Fracture line not visible 4 mo. after injury

* C-1 refers to atlas.
† C-2 refers to axis.
‡ Time from accident to last communication or examination.

§ Private case.
‖ Private case of G. M. Taylor, M.D.
¶ Private case of F. M. McKeever, M.D.

≠ Private case of M. Downs, M.D.

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A New Technique in Rhinoplasty

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In this short article I have described a technique of rhinoplasty which I have employed, I believe, with success. I have not come across any writing describing such a technique as having been adopted by any other surgeon. The essential feature of this technique is that the pedicle skin graft which is used for constructing the new nose is prepared in such a way that when it is sutured in its new position the nose retains its shape, size, and contour without the aid of any rigid support, like the cartilage graft or an ivory piece, and the nostrils remain patent.

The oldest method of rhinoplasty—known as the Indian technique—in which a flap of skin from the forehead is utilized to make a new nose, has one great drawback. It is that after a time, although the skin remains viable and normal looking, the nose falls, and there remains a completely flat nose. In fact it is not a nose at all. It is just a piece of skin in place of the original nose. The other drawback is the occlusion of the nostrils due to adhesions forming between the raw surfaces on the inner side of the nostrils.

In the Italian method, introduced by a surgeon named Gaspard Taglacozzi, in 1597, a flap of skin from the arm is used to make the new nose; whereas in the French method flaps of skin are taken from the cheek for the formation of the new nose.

In all these methods both of the drawbacks persist.

In 1891, Keegan introduced a method of taking two flaps, one from each side of the nose, and an overlapping flap from the forehead. The flap thus became skin-lined on both the surfaces. Koenig, in 1886, and later Schimmelbusch and Lexer, introduced osteoplastic flaps taken from the forehead, whereas Nélaton tried to use a piece of costal cartilage as a supporting structure.

Whereas the use of cartilage necessitates additional operations involving the possibility of death of the cartilage graft, the employment of ivory or other nonliving grafts has the usual handicaps attached to the introduction of a foreign body. Similarly, double or folded skin grafts, used so that the graft may be skin-lined on both the sides, make the graft unwieldy and sometimes too thick. Taking grafts from the cheek or sides of the nose causes unnecessary and ugly scarring, whereas a double graft from the forehead is liable to twist the eyebrows and/or eyelids out of shape and cause disfigurement.

Whatever the method, it is now agreed that, if the nose is to retain its shape, size, and contour, and function, it must be kept rigid and the flap must be lined by epithelium on the inside also, if the nostrils are to remain patent. The technique used by Sir Harold Gillies has given satisfactory results.

In order to overcome the two main shortcomings already mentioned, i. e., flattening of the nose and occlusion of the nostrils, I tried an entirely new technique without the use of a cartilage graft or any other rigid material, and, although I have done only two cases, the results have been so encouraging that I believe that the technique deserves further trials.

TECHNIQUE

A negative plaster cast is made of the patient's face. From this a positive cast is made. With Plasticine a nose is now constructed on this positive cast, approximating the shape and size of the patient's original nose. Tin foil is then molded on this Plasti-

Submitted for publication July 27, 1955.

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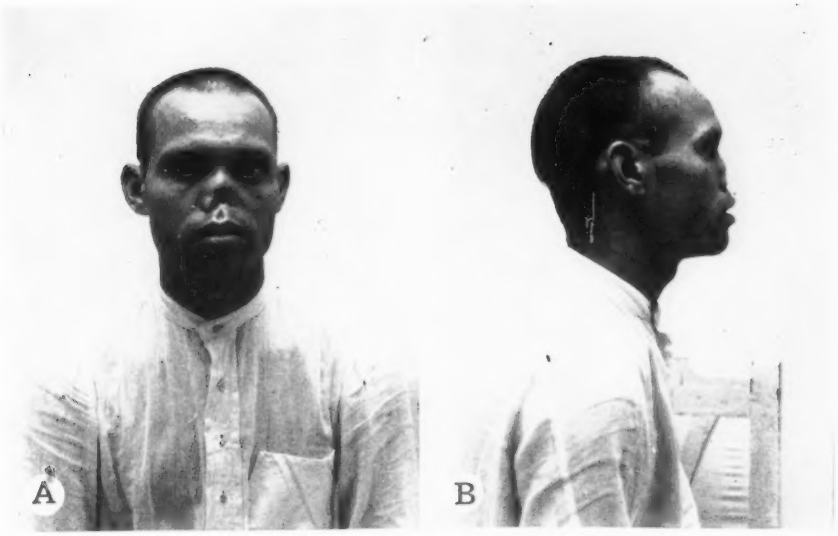

Fig. 1 (Case 1).—Photographs of patient with his nose cut off.

cine nose and cut to its shape and size. The tin foil is to be used later in the operation.

The Operation.—Stage 1: 1. The head of the patient is shaved and the usual preoperative preparations done.

2. When the patient is under general anesthesia, the forehead is cleaned with one of the usual skin antiseptics and towels are arranged. I use 3% acriflavine in alcohol for skin preparation. The tin foil is now laid on

Fig. 2 (Case 1).—Photograph showing the pedicle graft from the forehead.

Fig. 3 (Case 1).—Photograph showing the pedicle graft sutured in place of the original nose and the pedicle intact.

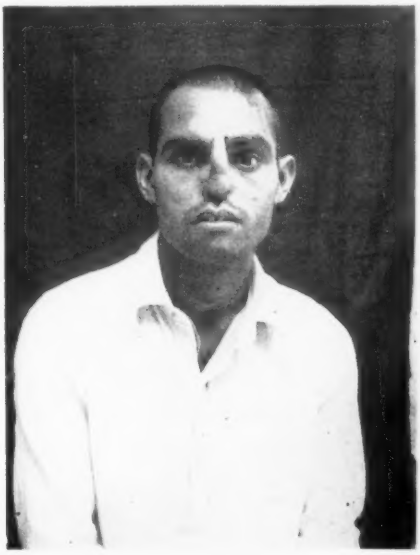

Fig. 4 (Case 1).—Photograph showing the new nose with the pedicle cut off.

Fig. 6 (Case 2).—Photograph showing the patient with his nose cut off.

one side of the forehead, and a graft a little bigger than the size of the tin foil is cut from the frontal region. The graft has its pedicle attached to the medial side of that eyebrow, so that it receives an adequate blood supply from the angular vessels of that side.

3. The edges of the forehead wound are approximated as much as possible. The raw surface of the graft and the remaining raw surface of the forehead wound are covered with Thiersch grafts taken from the thigh.

4. The grafted forehead wound is dressed and allowed to heal in the usual way. The sutures are removed in the usual course.

Fig. 5 (Case 1).—Photograph showing the condition of the nose after four years. The second patient unfortunately died two years after the operation owing to some lung disease not connected in any way with the operation.

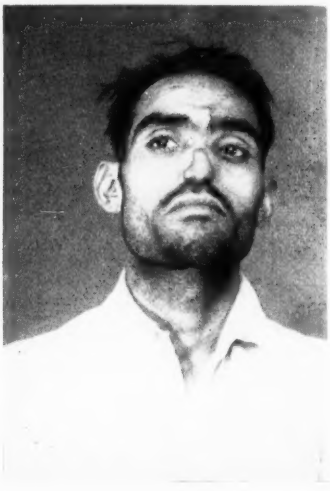

Fig. 7 (Case 2).—Photograph showing the pedicle skin graft from the forehead.

Fig. 8 (Case 2).—Photograph showing the pedicle graft sutured in place of the original nose and the pedicle intact.

5. The pedicle graft is turned and pinned on a piece of light wooden board, so that the skin surface is in contact with the board and the grafted surface is exposed. No dressings are applied on the Thiersch-grafted pedicle graft, but it is kept enclosed in a wire mesh to prevent contamination. The grafts take in about 10 to 15 days. The pedicle graft has now an epithelial surface on both sides. The pedicle graft is allowed to remain like this, pinned on the board, for about one month. During this time it contracts and it also gets thick. This is the essential feature of the technique. The idea is to allow the graft to fibrose, consequently contract and thicken, but not contract out of shape. In fact, at the end of one month it gets so firm that, although it remains malleable, it retains its contour when it is molded into a particular shape.

Fig. 9 (Case 2).—Photograph showing the new nose with the pedicle cut off.

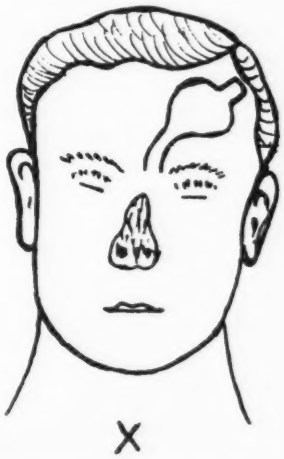

Fig. 10.—Drawing showing the site of the skin pedicle graft.

STAGE II.—The second stage is undertaken when the nose and face are clean. The edges of the pedicle graft and those of the cut margins of the nose are pared. The graft is then swung into position, molded into the shape of the nose, and sutured in place of the original nose, with the original skin on the outer side and the Thiersch-grafted surface on the inside, i. e., lining the nostrils. A thick-walled rubber tube is kept in each nostril, for the following dual purpose: 1. to allow breathing and 2. to act as a support.

After five to seven days all the sutures are removed. When the suture line is completely healed, dry, and clean and the edges are well

united, and at the end of three weeks from the time of suturing, a small cut is made in the pedicle, as near the nose as possible. About twice a week a little more of the pedicle is cut, so that by the end of about two weeks the pedicle is completely cut through and the new nose now receives its blood supply from its attachment to the face. The end of the pedicle is turned up and sutured to the forehead wound if necessary, to cover any raw surface. If the skin is redundant, it is excised. Near the nose it is cut in a bevel and sutured to the nose, so that the anterior surface becomes even. The tubes are also removed.

Such a nose retains its shape, it has no tendency to fall flat, and the nostrils remain patent. The only defect in such a nose is that it has no sensation; even if it be pinched, the patient does not feel it.

SUMMARY

A very brief historical review of the different techniques of rhinoplasty is given—the Indian method of forehead flap, the Italian method of arm flap, and the French method of cheek flaps are mentioned. The two main drawbacks of these methods are also pointed out. Keegan's method of double flaps, Koenig, Schimmelbusch, and Lexer's method of osteoplastic flaps from the forehead, and Nélaton's introduction of costal cartilage as a supporting structure are also mentioned.

The technique employed in my two cases is described in detail.

The two cases treated by this method are illustrated by photographs in all the four stages, and one patient is shown as he looked four years after the operation.

The method of making the forehead skin pedicle graft is diagrammatically illustrated.

6-A Nasroji Gamadia Road (26).

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Complications of the Surgical Treatment of Chronic Ulcerative Colitis

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The percentage of patients with chronic ulcerative colitis in whom surgery is indicated will vary with the severity of the disease and the length of time which these patients have been followed. In our experience 40% of patients with chronic ulcerative colitis will require surgical intervention either because of a complication of the disease or because they have failed to respond to medical treatment. Internists, gastroenterologists, and surgeons alike have learned to recognize those patients with severe chronic ulcerative colitis who will not survive unless their disease process is removed surgically. They have also learned to recognize those patients who will survive only as chronic invalids, unable to continue in school or to earn a living because of malnutrition, chronic anemia, or general debility so often associated with this long-standing disease.

Experience has also demonstrated that in the great majority of patients who require surgical intervention a permanent ileostomy and complete colectomy will be necessary. When the disease is so severe that an ileostomy is required, subsequent restoration of intestinal continuity is rarely possible. Even if healing occurs in the defunctionalized colon, the normal bowel is replaced by a thickened, rigid tube with a greatly diminished lumen which is quite incapable of normal function. It is of value, therefore, to know the type and incidence of complications that may be associated with ileostomy and colectomy in patients operated upon for chronic ulcerative colitis.

We have reviewed the clinical records of 307 patients who were submitted to ileostomy and colectomy between 1946 and 1954. All complications associated with the surgical management of these patients have been evaluated, and their treatment and prevention are discussed.

Considerable emphasis has recently been placed upon the advisability of carrying out colectomy at the time the ileostomy is established in all patients with chronic ulcerative colitis. We believe that in the seriously ill patient an ileostomy alone can be done with a lower mortality than ileostomy plus colectomy. However, in patients who are reasonably good operative risks, who are in the chronic cicatricial stage of the disease, or who are being operated upon because of intractable diarrhea, incompetent anal sphincter, the development of arthritis, obstruction, or carcinoma, subtotal colectomy may be combined with ileostomy without increasing the operative mortality.

With better appreciation of the type of patient who will require surgical intervention, and with the aid of corticotropin (ACTH) and cortisone, which often will induce a temporary remission in cases of acute, fulminating ulcerative colitis, more and more of our patients are having a combined ileostomy and subtotal colectomy. (Later the rectum and rectosigmoid are removed by abdominoperineal resection.) Before 1947, colectomy was carried out at the same time as ileostomy in only 2.6% of patients oper-

Submitted for publication Aug. 31, 1955.

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ated on for chronic ulcerative colitis, whereas in 1953 and 1954, the last two years of this study, it was carried out in 36.8%. That this combined procedure has not increased the incidence of complications is shown by the fact that there were 78 complications (37.8%) in the 206 patients submitted to ileostomy and colectomy in stages, and 40 (39.6%) in the 101 patients submitted to a combined ileostomy and subtotal colectomy.

Although the incidence of complications associated with ileostomy has remained essentially unchanged, the mortality has been appreciably reduced (17.7% before 1947 to 4.3% since 1947). This decrease lends support to our clinical impression that complications associated with the surgical treatment of patients with chronic ulcerative colitis tend to be less serious today because of earlier recognition and more effective treatment. The fact that the incidence of complications remains high, however, emphasizes the fact that the surgical treatment of these patients is associated with a number of potentially serious complications which must be recognized early and treated promptly if the present low mortality rate is to be maintained.*

TYPE OF COMPLICATION

Skin Irritation.—Irritation of the surrounding skin, sometimes of an extreme degree, has always been a complication of ileostomy. In 49 (15.9%) of this group of 307 patients, some degree of skin irritation developed. This complication occurred in only 12 patients while they were still in the hospital, indicating the need for careful instruction of these patients regarding the care of the skin after their discharge. The fact that only 6 of the 49 patients who were operated upon during the last five years had this complication reflects the value of skin care beginning in the operating room at the time the ileostomy is established, plus the early application of the modern ileostomy bag. With careful placement of the ileostomy and secure fitting of the ileostomy bag, it is now possible to prevent most of these instances of early and late skin irritation.

Postoperative Electrolyte Imbalance.—Electrolyte imbalance and deterioration in the general condition of the patient may occur at any time in the postoperative period. In cases of hyperfunctioning ileostomy, a large amount of sodium, potassium, and chloride may be lost rapidly in the fluid discharge. Abdominal cramps associated with a small amount of clear watery discharge indicate partial obstruction of the small bowel. Careful attention to any alteration in the character or amount of the ileostomy discharge[4] and adequate replacement of fluid and electrolyte loss during this early postoperative period will usually prevent serious electrolyte imbalance. This complication occurred in 37 or 12% of this group. The fact that it occurred in 15 of the 37 patients following their discharge from the hospital indicates the necessity of carefully instructing these patients regarding the need for adequate intake of fluid and salt after they return home. They must be warned to keep in close contact with their surgeon or family physician so that if their ileostomy fails to function properly or if abdominal cramps or vomiting occurs they will seek help before serious electrolyte imbalance results.

Obstruction.—In the past, some degree of small bowel obstruction frequently followed the establishment of an ileostomy. Often this obstruction was temporary and was relieved by catheter irrigation of the ileostomy combined with intubation by the Miller-Abbott tube. Obstruction occurred in 134 patients (43.6%) in 62 of whom it was temporary and was relieved by nonsurgical means. In 72 of the remaining 72 patients who required surgical intervention the obstruction developed after their discharge from the hospital. In many instances the obstruction was the result of a partial stricture at the site of the ileostomy and was relieved by a minor surgical procedure. Prompt recognition of minor degrees of obstruction in the early postoperative period and careful follow-up of patients after their discharge will appreciably reduce this high incidence of small bowel obstruction associated with ileostomy. This is indicated by the fact that in 1946, the first year of this

* References 1, 2, and 3.

study, there were 15 instances of small bowel obstruction, and in the last year, 1954, there were 2, only one of which required surgery. In this case the stricture occurred at the skin level seven months after the patient was discharged from the hospital.

Fistula Formation.—Fistulas in the side of the ileostomy represent a disturbing complication of this procedure, for they often interfere with, if not actually prevent, adequate fixation of the ileostomy bag. This is particularly true if the fistula occurs at or below the level of the skin. In such instances revision of the ileostomy will be necessary.

There were 68 (22%) instances of fistula formation. In 56 of the 68 patients the fistula occurred after the patient's discharge from the hospital, was above the level of the skin, and in many instances was due to necrosis from a too tightly fitting ileostomy bag. Fistula formation early in the postoperative period rarely occurs if no sutures are placed in the bowel wall and there is no constriction of the ileostomy by the layers of the abdominal wall. The danger of late fistula formation can be decreased by allowing a space of at least ¼ in. between the side of the ileostomy and the margin of the ileostomy bag opening and by warning each patient of the danger of pressure by the ileostomy bag on the side of the bowel should edema of the ileostomy occur. That progress is being made in the prevention of fistula formation, as with other complications of ileostomy, is shown by the fact that there were 22 fistulas in the 68 patients operated on in 1946 and 1947 and only 6 in the 53 patients operated on during 1953 and 1954. In many of these patients in whom a fistula develops late and in whom the level of the fistula is well above the skin, the fistula can be managed in the office by simply converting the two openings into one.

Prolapse, Retraction, and Hernia.—In the presence of ulcerative colitis fixation of the ileum to the abdominal wall is often imperfect, and prolapse of the ileostomy has been a common complication in patients with this disease. If care is taken to provide adequate fixation of the mesentery of the terminal ileum to the parietal peritoneum at the time the ileostomy is constructed, this complication will occur very infrequently. There have been no instances of prolapse of ileostomy during the postoperative period in the last five years. In should be noted that fixation is obtained by suturing the mesentery of the ileum rather than by placing sutures in the bowel wall itself.† Adequate fixation also tends to prevent late prolapse of the ileostomy, and in no instance has late prolapse occurred in the 97 patients who were operated upon from 1952 to 1954 inclusive.

Retraction may also result from inadequate fixation of the ileum to the abdominal wall, but this, too, can be prevented if care is taken to obtain adequate fixation of the ileal mesentery at the time the ileostomy is made. Retraction occurred in but 3.5% of the entire group and in only two instances since 1951. In both of these patients it reached the level of the skin and did not present a serious or emergency situation. Retraction to the level of the skin, however, will require revision of the ileostomy to permit watertight attachment of the ileostomy bag.

Postoperative hernia at the site of the ileostomy was not a common complication in our experience. It occurred in 4.2% of the entire group and in none of the 53 patients operated upon during the last two years. This was true in spite of the fact that many of these ileostomies were brought out the lower end of a right rectus incision.

Persistent Bleeding.— Although persistent bleeding should be considered a complication of the ulcerative colitis rather than of its surgical treatment, it is of interest that in only 3 of the 15 patients who had their ileostomy primarily for severe bleeding was the bleeding controlled by the ileostomy alone. In the remaining 12 an additional surgical procedure, partial or even complete colectomy, was required to stop profuse rectal hemorrhage. One patient was given 19 transfusions for a massive hemorrhage which occurred four years after ileostomy. This

† References 5 and 6.

case indicates another reason for carrying out colectomy, either subsequent to or at the time of ileostomy, in all of these patients who require surgical intervention.

Regional Ileitis.—Regional ileitis may occur in patients who have chronic ulcerative colitis, and, when it does, it is a very serious complication. One of our early patients who was co-developer of an ileostomy appliance in common use at the present time has just succumbed 18 years after his initial operation for ulcerative colitis associated with regional ileitis. All of his colon and eventually all but 3 or 4 ft. of small bowel had to be removed because of the persisting inflammatory process. In recent years he required repeated hospitalization because of the difficulty of maintaining proper electrolyte balance. Finally he had an episode of fluid and electrolyte imbalance from which he did not recover.

It cannot be stated definitely whether or not these two conditions are two distinct entities. From a pathological standpoint there is some reason to believe that they are.[7] From a clinical point of view it must be noted that they frequently coexist, and when they do they present an exceedingly difficult problem from the standpoint of surgical management. Regional ileitis often leads to excessive function of the ileostomy, resulting in electrolyte imbalance or serious skin irritation. It frequently produces small-bowel obstruction. If it involves the stoma, the ileostomy must be revised and the infected ileum removed. Since chronic ulcerative colitis often extends into the distal 3 to 6 in. of the terminal ileum, this segment of the ileum should always be removed when ileostomy and colectomy are carried out.

There were 10 patients in this group who developed extensive regional ileitis of sufficient severity as to require operative intervention in addition to their ileostomy and colectomy. In 5 of the 10 patients the regional ileitis followed the chronic ulcerative colitis, in 4 it appeared to be coexistent, and in one patient the chronic ulcerative colitis occurred six years after the small bowel was resected for ileitis. In one patient this chronic inflammatory process of nonspecific origin involved successively the colon, the small bowel, and the stomach. Another patient has had esophageal involvement in addition to involvement of the small bowel and colon and has required repeated esophageal dilatations.

Pregnancy.—Since this disease affects young persons, the question of pregnancy frequently arises in patients who have been subjected to ileostomy with or without colectomy. Ten of our patients became pregnant after their ileostomy, five of whom had normal deliveries through the birth canal at or near term. Acute exacerbations of the ulcerative colitis occurred in two patients, and one of the two had a spontaneous abortion. Two patients required therapeutic abortion, and one patient died of eclampsia at term. It was significant that in all five patients in whom the pregnancy was complicated a part or all of the colon remained. For this reason we believe that patients who have not had their diseased colon and rectum removed should be advised to wait until colectomy has been carried out before they become pregnant. Although in our experience no permanent harm has occurred to the ileostomy as a result of pregnancy, some disturbances of normal ileostomy function frequently develops during the last trimester of pregnancy, and repeated pregnancies are probably unwise.

Carcinoma.—In recent years there has been an increasing appreciation of the frequency with which carcinoma may complicate chronic ulcerative colitis. In this group carcinoma of the colon developed in association with ulcerative colitis in 11 patients, an incidence of 3.57%. In two patients an unsuspected carcinoma was found in a specimen after resection for colitis, and in the remaining 9 patients carcinoma developed after ileostomy. In our experience this incidence of carcinoma is greatly increased if only those patients are considered who have had colitis for 8 to 10 years or more.‡ When carcinoma does occur, the prognosis is poor.

‡ References 8 and 9.

Patients with chronic ulcerative colitis are accustomed to such symptoms as rectal bleeding, changes in bowel habit, and abdominal discomfort, and these symptoms of carcinoma of the colon or rectum are likely to be ignored. Moreover, the markedly increased vascularity and lymphatic drainage of the colon permit early and wide dissemination of the cancer cells. This danger of malignant disease offers an additional reason for carrying out total colectomy in all patients who require ileostomy for chronic ulcerative colitis. It also means that any patient who has had chronic ulcerative colitis for 8 to 10 years or more and who has not had a colectomy runs a very real risk of developing carcinoma in his diseased colon and must be followed closely with this complication in mind.

MISCELLANEOUS COMPLICATIONS

Infection of the ileostomy incision occurred in seven patients and dehiscence in five. Subdiaphragmatic abscess developed in two patients, pneumonia in two, toxic cirrhosis in one, and a nonfatal coronary thrombosis in one.

There were 15 transfusion reactions. Six were early reactions and included urticaria, chills, fever, and pain; the nine late reactions consisted largely of urticaria. This latter group included three patients with homologous serum jaundice. There were no instances of oliguria or anuria following transfusion, and, since many of the 307 patients required numerous transfusions, the incidence of serious reactions was satisfactorily low.

RECURRENCE OF DISEASE

Recurrence of the ulcerative colitis has always represented a serious hazard to the surgical treatment of ulcerative colitis whenever a segmental resection has been carried out or when intestinal continuity has been restored after a temporary ileostomy. Five patients in this group had a right colectomy with primary anastomosis for what seemed to be localized ulcerative colitis. Two of these patients have remained well two and three years, respectively. Seven patients had intestinal continuity restored after a temporary ileostomy, and two of these patients have remained well for three years. The remaining eight patients have required a permanent ileostomy and colectomy for recurrent disease.

It seems reasonable to treat ulcerative colitis which is limited to the right colon by right colectomy, with immediate restoration of intestinal continuity. It must be kept in mind, however, that in actual practice this procedure has been associated with a high incidence of recurrence owing to the fact that it is difficult to determine, even by careful observation at operation, how far the disease in the colon actually extends.

For the same reason a colostomy has proved unsatisfactory for ulcerative colitis, even for those patients with disease apparently limited to the distal colon and rectum. Two patients were treated by abdominoperineal resection for disease which seemed to be limited to the rectum and rectosigmoid. One of these patients has been lost to follow-up, and the other has required ileostomy and colectomy for recurrent disease.

It is also extremely difficult to determine when this disease has truly died out, after the colon has been defunctionalized for a period of time by an ileostomy. In our practice intestinal continuity was restored after a temporary ileostomy only in patients who had had no symptoms for an entire year, whose colon appeared normal at the end of that time on barium enema examination, and whose rectum appeared normal on proctoscopic examination. In spite of these precautions, recurrence developed in approximately two-thirds of these patients, and further surgical procedures, namely, a second ileostomy and a colectomy, were required.

STAB-WOUND ILEOSTOMY

An attempt was made to determine whether exteriorization of the ileum through a small stab wound had any advantage over bringing the ileum out through the operative incision. Forty-five patients had a stab-wound ileostomy, and 262 patients had the ileum brought out through the lower end of the incision. Theoretically, it would seem that

the ileostomy bag would fit more securely if it did not rest on a laparotomy incision, and, indeed, the incidence of skin irritation appeared to be somewhat lower (8.8%) in the group who had a stab-wound ileostomy than in the group in which the ileostomy was brought out the laparotomy wound (16.4%). It has been our experience, however, that, if the operative incision is carefully closed with approximation of the subcutaneous tissues, the incision itself rarely interferes with proper fixation of the ileostomy bag. On the other hand, the incidence of obstruction appeared to be higher in those patients who had a stab-wound ileostomy (55.4%) than in those whose ileostomy was brought out through the incision (40.7%). Additional operative procedures were necessary in 33.2% of the group who had a stab-wound ileostomy and in only 21.7% of the patients in the other group. The incidence of obstruction at the skin level also was higher in the patients with a stab-wound ileostomy (20%) than in the larger group (9%). The incidence of fistula, prolapse, and retraction was essentially the same in both groups. This indicates that, if a stab wound is made, it must be made large enough so that it will not constrict the ileostomy when it heals. It is well to remove a circular segment of skin and to incise the fascia in two directions.

MORTALITY

Eleven patients (3.8%) died in the hospital after ileostomy or colectomy, and twenty-three patients died after discharge from the hospital, giving a total, or absolute, patient mortality of 11.1%. This included deaths from such causes as uremia, diabetic coma, pulmonary embolus, periarteritis nodosa, rheumatic heart disease, coronary thrombosis, monocytic leukemia, bacterial endocarditis, and carcinoma.

SUMMARY AND CONCLUSIONS

Three hundred seven patients operated on for ulcerative colitis from 1946 to 1954 inclusive have been studied from the standpoint of complications associated with their surgical treatment.

In order to permit more accurate evaluation, all degrees of complications, minor, moderate, and severe, were included. The incidence of skin irritation, electrolyte imbalance, obstruction, and fistula formation emphasizes the importance of these complications in the surgical treatment of this disease. With improvement in technique and attention to detail during the establishment of the ileostomy plus vigilant care during the postoperative period, the incidence and seriousness of incidence of early postoperative complications have been appreciably reduced.

A well-instructed patient who is aware of the complications which may be associated with an ileostomy and who is backed by the continued interest of his or her surgeon is not likely to develop a late complication of a serious nature.

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When Will He Wake Up?

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General anesthesia differs from natural sleep in that the person who is simply asleep can always be wakened immediately by stimulation, whereas the narcotized patient must go through a recovery period, during which the depressant drug is detoxified or excreted. During this period, it is not possible to waken him by simple methods or by any means at our command. In the absence of stimulation of any kind, of course, there is a certain similarity between the two, for both the sleeping person and the anesthetized patient will remain unconscious for fairly constant periods of time. "When will he wake up?" is a question that has too long remained unanswered and has usually been met with evasive, or at best inexact, replies. A series of 300 consecutive cases is offered here, comprising a study undertaken to answer this question.

In the first place, there was a healthy curiosity concerning the average duration of the waking period. Then there was another kind of curiosity as to why some patients woke up quickly while others slept for hours. The study was prompted in part by relatives of the patient asking "when will he wake up?," by the physician's being asked by the patient why it took him so long to awaken, and by the surgeon who occasionally wanted to know, for practical reasons or merely out of his own curiosity, when the patient would be awake. Occasionally a patient is brought to the operating room for a minor procedure, and the surgeon says that the patient would like to go home later that day; it was hoped that the study would yield information to guide the anesthetist in selecting the agent or method so as to shorten the waking time for this purpose. Exact knowledge of waking periods could tell us, in the case of a patient who was still unconscious three or four hours after surgery, whether he was in trouble and might require serum albumin for cerebral edema or whether he was all right and just passing through a normal waking period. Information of this kind might guide the anesthetist in choosing his anesthetic method and perhaps in stopping the administration of anesthesia a calculated number of minutes before the anticipated end of the operation. Knowing what the waking periods are for different techniques may advise the anesthetist in any case in selecting his methods; it may enable him to manage the postanesthesia room more efficiently by shortening the waking period; it may reduce the amount of nursing care required, and, finally, it is at least theoretically possible that a shorter waking time may be associated with a lower mortality rate.

Attempts were made to explore the possibility of correlation between waking periods and any of the following factors: the anesthetic agent, combinations of agents, technique, intubation, curare, the operation (some require deep anesthesia, some allow lightening before the end whereas others do not), duration of surgery, age of patient, sex of patient (about 57% were female), physical condition of the patient, the surgeon (some take longer than others and demand deep anesthesia, and their patients will sleep longer), and the anesthetist.

Submitted for publication June 5, 1955.

It was believed from the beginning that long operations would be followed by long waking times, and this was generally confirmed. Several end-points were considered: extruding the airway, moving any part of the body, swallowing, opening the eyes, talking of any kind (or children's crying), nodding sensibly in response to questions, and talking intelligently. Only sensible responses were used, including intelligent talking (crying was accepted in children) and head nodding or shaking to answer questions; earlier, less significant reactions, such as swallowing and moving, have been reached in many reported cases where there was no further waking and no return to consciousness.

A considerable amount of inaccuracy may be involved in fixing the end-point. Many patients will sleep or appear to sleep for hours unless stimulated. Often a patient who seems to be fast asleep and who, according to his nurse, has not yet responded can be quickly awakened on being spoken to in a loud voice. A patient who continues to tolerate an artificial airway and who has shown no sign of reacting can sometimes be made to eject the airway, grimace, open his eyes, and even speak. The end-point may be said to have been hurried in the one case or to have been carelessly put off in the other; uniform technique or a large number of cases is required.

An analysis of the 300 consecutive cases is presented in Table 1. The "ratio" referred to here and elsewhere in the article is the amount obtained by dividing the waking time by the anesthesia time, expressed in percentile form. This was found to be of some value. "Anesthesia time minus waking time" was calculated to see if the waking period could be predicted on the basis of a simple numerical difference, such as being 10 (or any other constant number) minutes less than the duration of surgery; no such correlation was found. The average duration

TABLE 1.—*Statistical Analysis of 300 Consecutive Cases*

	Anesthesia Time, Min.	Waking Time, Min.	Ratio, per Cent	Anesthesia Time Minus Waking Time
Range	4-280	0-150	0-380	—50-232
Mode	25	15	0-20	5-29
Average	58.8	24.0	55.7	34.8
Median	42	19	39	21.5
Total	17,629	7,203	16,702	10,426

TABLE 2.—*The Twenty-Four Techniques*

Anesthetic	Cases	Average Waking Time, Min.	Average Ratio (Waking Time/ Anesthetic Time), per Cent
1. Thiopental, N_2O	37	17.5	56.0
2. Thiopental, N_2O, curare	32	29.5	63.6
3. Thiopental, N_2O, curare, intubated	8	56.0	50.4
4. Thiopental, oxygen	1	4	16
5. Thiopental, oxygen, curare	6	31.5	68.75
6. Thiopental, cyclopropane	46	16.8	53.0
7. Thiopental, cyclopropane, curare	41	22.4	37.0
8. Thiopental, cyclopropane, curare, intubated	11	35.8	23.8
9. Thiopental, ether	4	45.75	87.1
10. Thiopental, ether, curare	2	24.5	42.2
11. Thiopental, ether, curare, intubated	1	126	90
12. Thiopental, cyclopropane, ether	4	37	39.1
13. Thiopental, cyclopropane, ether, curare	8	42.9	41.7
14. Thiopental, N_2O, cyclopropane, curare	2	14	14.95
15. Thiopental, N_2O, ether	3	9.7	12.2
16. Thiopental, N_2O, ether, curare	2	57.5	49.75
17. Thiopental, N_2O, ether, curare, intubated	2	52.5	35.75
18. Cyclopropane	1	5	20
19. Cyclopropane, curare	1	5	6.25
20. Cyclopropane, ether, curare	3	26.7	20.8
21. Drop ether, air	3	15	70
22. Drop ether, oxygen	10	14.1	31.8
23. Divinyl ether, drop ether	9	21.6	52.6
24. Divinyl ether, drop ether, ether insufflation	63	20.4	81.7

of anesthesia was about an hour. The average waking time was 24 minutes.

The 24 different techniques used are listed in Table 2. The effect of curare and that of endotracheal intubation can be observed by comparing Lines 1, 2, and 3, and also Lines 6, 7, and 8. In the first group of techniques, with thiopental (Pentothal) sodium plus nitrous oxide, the waking time was apparently increased by curarization and by intubation. It must be remembered, however, that operations requiring curare are usually more difficult and longer than others; this is also true of intubation. There is no serious change in average ratios. In the cyclopropane (with thiopental induction) group the waking times again increase, but the ratio diminishes; it will be shown later that the ratio always tends to decrease for longer procedures. In general, it appears that curarization does not make patients sleep longer, and intubation is at least equally innocent; a patient very likely wakes up more quickly if he is intubated than if he is not. The 24 techniques are regrouped according to the three commonly used agents.

In Table 4 average waking times for patients receiving each of the three agents are further subdivided to show the relation to the length of anesthesia.

TABLE 3.—*Waking Periods for Different Anesthetics*

Anesthetic		Cases	Average Waking Time, Min.	Average Ratio, per Cent
Thiopental		84	26.6	59.5
Cyclopropane		102	20.9	41.9
Ether	all cases	114	25.0	65.2
	adults	29	40.6	44.2

TABLE 5.—*The Laparotomies*

Technique	Cases	Average Waking Time, Min.	Average Ratio, per Cent
Intubated	4	19.0	14
Ether			
All cases	14	24.6	31.1
Adults	11	28.5	31.8
Thiopental	8	39	61.5
Cyclopropane	27	19.9	31.4
Curare	42	25.7	38
All cases	49	24.4	36.2

Forty-nine laparotomies are listed in Table 5. The following facts are to be noted:

1. The curarized cases do not differ significantly from the others.

2. The intubated cases—and curare was used in all of these—were associated with shorter average waking times and also smaller average ratios.

3. The average waking times (in minutes) were 20 for cyclopropane, 25 and 28.5 for ether, and 39 for thiopental. The per cent ratios were 31.4 for cyclopropane, a little more than 31 for ether, and 61.5 for thiopental.

4. The average waking time for all laparotomies was 24.4 minutes.

A list was prepared of all 300 cases in order of duration of waking time, and the ones taking longest time, more than an hour and a half, were singled out to see if they presented anything in common. There were three long-waking-time cases, and they all turned out to be laminectomies. Figures for the long-waking cases and for all laminectomies are given in Table 6. Laminectomies are fairly long procedures, they require a considerable period of positioning after intu-

TABLE 4.—*Average Waking Times for Each Agent, in Relation to Length of Anesthesia*

	Thiopental		Cyclopropane		Ether	
	Average Waking Time, Min.	Cases	Average Waking Time, Min.	Cases	Average Waking Time, Min.	Cases
Less than 1 hr.	22.75	53	17.1	61	19.3	83
1 to 2 hr.	31.8	23	24.0	28	40.5	15
2 to 3 hr.	38.0	8	32.1	8	43.9	14

TABLE 6A.—*The Long-Waking Cases*

Waking Time, Min.	Ratio, per Cent	Anesthetic	Operation
110	95.7	Thiopental, N_2O, ether, curare	Laminectomy
126	90.0	Thiopental, ether, curare	Laminectomy
150	140.2	Thiopental, N_2O, curare	Laminectomy

bation before the incision can be made, and they do not permit lightening of the anesthesia (above the level necessary to maintain the endotracheal catheter in place without "bucking"), until the dressing has been applied and the patient turned to the supine position.

Since thiopental seemed to make patients sleep long, the cholecystectomies were collected to see if gall-bladder disease and perhaps related liver dysfunction caused slow detoxification of thiopental. There were nine cholecystectomies, and the figures for waking times and waking-sleeping time ratios are given in Table 7. The increase in waking time was from 20.9 minutes for cyclopropane to 26.6 minutes for thiopental for all cases, a relative prolongation of 27.2%. For cholecystectomies the increase was from 29 minutes for cyclopropane to 49.5 minutes for thiopental, a relative prolongation of 70.7%.

TABLE 6B.—*The Laminectomies*

	Cases	Average Waking Time, Min.	Average Ratio, per Cent
Total	11	73	56.7
Without cyclopropane	6	97.7	78
With cyclopropane	5	44.2	31.3

TABLE 7.—*The Cholecystectomies*

Anesthetic	Cases	Average Waking Time, Min.	Average Ratio, per Cent
Cyclopropane	3	29	46.5
Thiopental	4	49.5	63.9
All	9	37.5	52.2

In Table 8 the average waking times and ratios are shown for operations of different lengths. The ratios break down nicely into two-thirds, one-third, and one-fourth, or, in twelfths, eight-twelfths, four-twelfths, and three-twelfths, suggesting a simple relationship and attesting to the validity of the study.

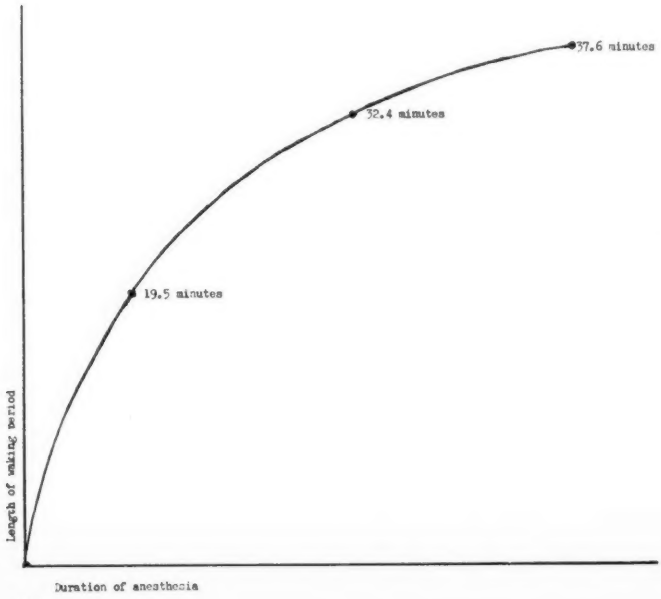

Fig. 1.—Waking time-anesthesia time curve. Operations lasting less than one hour range from 0 to 60 minutes and are therefore plotted at an average of 30 minutes. Similarly, one- to two-hour procedures are plotted at 90 minutes, and the two- to three-hour cases are placed at 150 minutes. Visual extrapolation suggests that average waking times for longer-waking cases than those shown here will not go far (if at all) above 40 minutes.

TABLE 8.—*Effect of Duration of Anesthesia on Waking Time*

Duration of Operation, Hr.	Average Waking Time, Min.	Average Ratio, per Cent
Not exceeding 1	19.5	66.5
1 to 2	32.4	35
2 to 3	37.6	25

It was apparent, as had been anticipated, that long waking times were associated with long operations, and it was hoped that a simple relationship could be obtained. The most obvious prediction for the waking period was something like one-half the anesthesia time, but this did not prove to be accurate.

A more exact estimation of the waking period, and a fairly simple relationship, is this:

waking time=1/6 anesthesia time+15 minutes

An even better formula, and one that exhibits the hyperbolic plateau (more nearly an asymptote) characteristic of the curve is this:

$W=\frac{50A}{A+50}$ where W is waking time and A is anesthesia time, in minutes. The values listed in Table 8 are presented graphically in the Charts, to show that they do lie on a smooth curve.

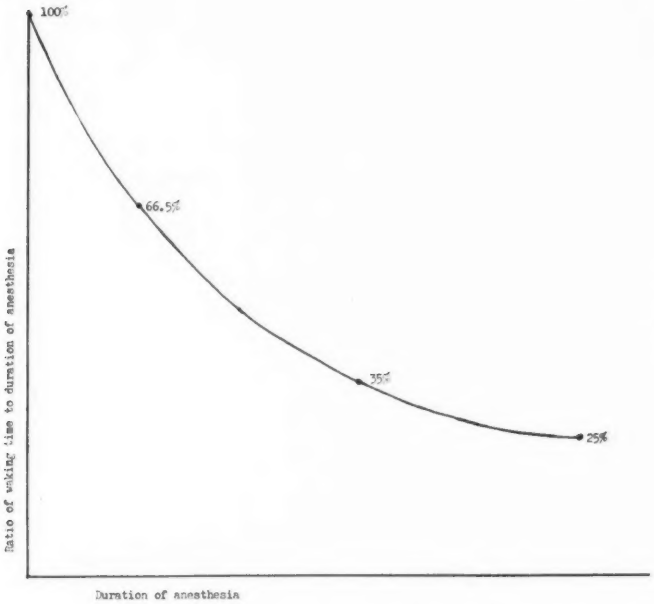

Fig. 2.—This curve illustrates the progressive shortening of the ratio of the waking time to the anesthesia time. Operations are plotted as in Figure 1.

SUMMARY AND CONCLUSIONS

The following observations and conclusions have resulted from this 300-case series:

1. Eye opening and airway extrusion occurred equally quickly.

2. All patients woke up within a half-hour of any response sign.

3. Laparotomy patients were generally awake in half an hour; none slept over 65 minutes.

4. Conclusions were reached in five factors explored for correlation with waking time as follows:

(*a*) The anesthetic agent. Thiopental (Pentothal) sodium seemed to be associated with long waking periods in this series, whereas cyclopropane patients woke up first. Average minute-figures (regardless of the duration of anesthesia) for waking periods were 21 for cyclopropane, 25 for ether, and 27 for thiopental (N_2O). Thiopental may

be associated with long waking times in lengthy procedures, cholecystectomy, and laminectomy.

(*b*) Intubation. No increase in the waking period was found.

(*c*) Curare. No increase in the waking time was found. Curare has never been shown to have anesthetic properties; in fact, its use provides for lighter anesthesia, since without it the relaxation would be produced by a higher concentration of the anesthetic agent.

(*d*) The operation. Cholecystectomy patients apparently sleep longer than the average if thiopental is the anesthetic drug. Laminectomy patients sleep long, particularly in noncyclopropane cases.

(*e*) Duration of surgery. A definite relationship was found here. Waking times increased with the length of the operation and appeared to be reaching a plateau. The duration of anesthesia being represented by A, then $\frac{A}{6} + 15$ or $\frac{50\,A}{A + 50}$ are fair approximations of the waking period, in minutes.

5. There were no deaths in the series.

6. No patient slept more than two and one-half hours.

7. The average waking time was 24 minutes.

Chronic Duodenal Obstruction from Ingested Fruit Pits in Patients with Duodenal Ulcer

Report of Two Cases

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The inadvertent ingestion of fruit pits is always attended by the possibility of mechanical ileus, although in most instances, unless the pit be extremely large, viz., a peach stone, or the subject a child, progression through the intestinal tract is prompt and asymptomatic. When impaction does occur, the site is usually a region of narrowing or flexure, e. g., the pylorus, the duodenojejunal flexure, or the ileocecal valve. However, in persons with gastrointestinal disease, the pit may be arrested in an area of pathology, viz., stenosis, stricture, or at a gastrointestinal anastomosis. This hazard is particularly great in patients with longstanding duodenal ulcers. In such subjects the pit may be stopped by a duodenal stenosis. The following case reports are presented to illustrate the latter phenomenon.

REPORT OF CASES

CASE 1.—A 49-year-old man in 1939, required hospitalization for melena. Gastrointestinal studies done at that time revealed a duodenal ulcer. Thereafter, the patient suffered periodically from heartburn, hunger and night pain, and postprandial gnawing epigastric pain radiating through to the back. There was no vomiting, no hematemesis, and no subsequent melena. No attack lasted more than one week; complete relief was always obtained by bland diet supplemented with antacids. Repeated gastrointestinal x-rays on several occasions disclosed duodenal deformity.

About seven years ago, the patient began to have a different type of dyspepsia. He experienced attacks of sharp colicky right upper abdominal pain which radiated bilaterally and subcostally to the shoulders. This pain typically occurred about two hours after greasy meals and especially at night. The pain was associated with belching, heartburn, nausea, and vomiting. There was no hematemesis, melena, diarrhea, chills, fever, or jaundice. Relief was afforded by vomiting and antispasmodics, and, on occasion, injection of morphine was necessary. A Graham test showed gallstones. In 1948, a cholecystectomy was done for chronic cholecystitis and cholelithiasis. Six months later, the patient was reexplored because of persistent attacks of colic which were associated with chills, fever, and jaundice. A single large faceted stone was removed from the common duct. At this operation, the duodenum was found embedded in a mass of adhesions and the head of the pancreas was markedly enlarged and indurated. There was no evidence of an active duodenal ulcer.

The patient was free of symptoms until April, 1952, at which time he began to have a recurrence of his previous ulcer complaints, though rarely he did experience typical biliary colic. There was no hematemesis, melena, chills, fever, or jaundice. His symptoms did not respond to the usual bland diet, although at no time did he strictly adhere to an ulcer regimen nor did he give up smoking two to four packs of cigarettes daily. Repeated barium-meal examinations always showed a marked duodenal deformity, but no ulcer crater could be demonstrated. Barium enema examinations were negative.

The patient's symptoms became progressively worse. He gradually lost 40 lbs. The pain increased in severity until it was continuous, colicky in character, and radiated through to the back. A secretin test was done to determine the patency of the biliary tract and the state of pancreatic function. Duodenal intubation was performed on Nov. 30, 1953. Only after the most vigorous fluoroscopic manipulation could the gastroduodenal tube be made to pass the

Submitted for publication July 5, 1955.

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pylorus and progress through the second portion of the duodenum. The secretin test findings were as follows:

A. Biliary pigment response—normal postcholecystectomy biliary flow

B. Pancreatic response

1. Volume—1.8 ml/kg. (normal 2.0 or more cc/kg.)
2. Bicarbonate—91 mEq/L. (normal 90 or more mEq/L.)
3. Amylase—11.9 units/kg.(normal 6.0 or more units/kg.)
4. Blood amylase—111 mg./100 cc. (normal 60 or more mg./100 cc.)

The test was interpreted as showing normal biliary flow with evidence of pancreatic duct obstruction. Because of the possibility of neoplasm a barium meal was administered (Figs. 1*A* and 1*B*). The esophagus and stomach were normal. At the base of the duodenal bulb was a sharply marginated elliptical defect measuring 2 cm. in length, with a peripheral zone of increased density. The remainder of the bulb was markedly deformed, narrowed, and distorted. A definite patch was not seen, but it was extremely difficult to compress this area because of the obesity of the patient and the tenderness over this region. A diagnosis of a plum pit impacted in a duodenal ulcer was made. When questioned about this, the patient admitted that he had swallowed a plum pit about 18 months previously and that all his complaints immediately followed this event.

It was presumed from the history and the x-ray findings that the patient had a plum pit caught between the pylorus and an obstruction in the duodenum resulting from his previous duodenal ulcer. The possibility of traumatic penetration of the pancreas was considered as the likely explanation of the abnormal secretin-test responses.

Fig. 1*A*.—Barium meal in Case 1 demonstrating elliptical shadow in the duodenum and the marked duodenal stenosis just beyond this shadow.

The patient was operated upon on Dec. 16, 1953, under spinal anesthesia. The entire upper abdominal cavity was oblitered by adhesions from the previous operations. When the duodenum had been mobilized, the pit could be readily located within it, caught, as it were, between the pyloric ring and a markedly stenotic area in the second portion of the duodenum (Figs. 1*A* and 1*B*). The head of the pancreas was very much enlarged and indurated. The rest of the pancreas felt normal. A gastric resection was not feasible because of the impossibility of obtaining a safe closure of the duodenum. Accordingly, a gastrotomy was done in the anterior wall of the pyloric antrum, and the pit was extracted through the pylorus with a stone forceps. Digital exploration of the duodenum through the pyloric canal revealed an almost complete obstruction low in the descending duodenum and a large ulcer penetrating deeply into the head of the pancreas. The pit had lain in the ulcer bed. The antrotomy was closed and a posterior gastrojejunostomy with bilateral vagisection was done as treatment for the duodenal ulcer and duodenal obstruction.

Fig. 1*B*.—High magnification of barium meal in Case 1 showing elliptical shadow in the duodenum outlined by barium and traversed by elliptical concentric lines. These are the roentgenologic characteristics of a pit in the intestines.

The postoperative course was stormy from the onset. The patient developed signs of atelectasis and pneumonic consolidation on the first day after surgery. Despite chemotherapy and repeated brochoscopic aspiration, he succumbed on the ninth postoperative day to suppurative bronchopneumonia. Postmortem examination revealed suppurative bronchopneumonia. The anastomotic lines were intact. The duodenum was markedly deformed and almost completely obstructed by a cicatricial stenosis. In the second portion of the duodenum there was a huge ulcer deeply penetrating the pancreas. The head of the pancreas was enlarged and indurated. The pancreatic duct was greatly dilated secondary

to obstruction caused by fibrosis of the head of the pancreas.

CASE 2.—A 50-year-old man was admitted to the consultation service in August, 1950, complaining of severe abdominal pains of six months' duration. His digestive symptoms started about 30 years prior to admission after attacks of dysentery and malaria contracted in Africa. He suffered from mild epigastric nonradiating crampy pain associated with nausea, heartburn, and, rarely, vomiting. The pain was aggravated by food and only slightly relieved by milk or bicarbonate. There was no

Fig. *2A*.—Barium meal Case 2 showing elliptic shadow in the pyloric antrum of the stomach.

Fig. *2B*.—Barium meal Case 2 showing elliptical filling defect in the duodenal bulb. Concentric striations can be identified in this film only by careful inspection.

hunger pain, night pain, or rhythmicity and no periodicity of symptoms. The patient had much flatulence but no hematemesis, melena, or fever and no jaundice. X-rays taken about 10 years ago were reported as showing a duodenal ulcer. Despite the recent exacerbation of complaints, there had been no weight loss.

Physical examination disclosed a well-nourished well-developed middle-aged man. There was no anemia and no joundice. Abdominal examination and rectal examination were normal.

Laboratory work-up revealed a normal blood cell count and a normal sedimentation rate. Fluoroscopy of the chest showed no evidence of parenchymatous lesions in the chest. The heart was normal in size and configuration. Barium meal (Figs. *2A* and *2B*) revealed a smooth elliptical defect measuring 2.5 cm. in length on the lesser curvature aspect of the prepyloric area of the stomach. Fluoroscopically and on the films, this polypoid lesion could be seen entering the base and middle of the duodenal bulb. At various times it was situated either in the duodenal bulb or in the prepyloric area of the stomach. A diagnosis of peduncleated polyp was made with intermittent prolapse into the duodenum.

The patient was explored in November, 1950. When the stomach was opened, an apricot pit was found, corresponding in size and shape to the defect described from the x-ray examinations. The pit had been unable to pass through the duodenum because of marked stenosis due to scarring of an old healed duodenal ulcer. A gastroenterostomy and bilateral vagisection were performed. The patient has been completely relieved of his symptoms. Upon subsequent questioning, he remembered, in retrospect, having swallowed the pit six months previously and also that shortly thereafter he noted exacerbation of his digestive complaints.

COMMENT

The cases reported demonstrate the bizarre symptomatology which may result from fruit-pit obstruction. Diagnosis may be very difficult unless the physician is oriented by a history of inadvertent ingestion. The clinical picture tends to be that of a recurring and remitting chronic intestinal obstruction because of the fact that the foreign body, being elliptical in shape, may be dislodged from the site of stenosis. At times, however, the pit may be so deeply embedded in the stenotic zone that complete intestinal obstruction supervenes. It is interesting to note that neither case showed evidences of intestinal obstruction. Rather, both patients complained of exacerbations of their previous symptoms of ulcer.

Case 1 illustrates an instance in which a plum pit was securely trapped between the pylorus and an area of marked duodenal stenosis secondary to the healing cicatrization of a peptic ulcer of many years' duration. The pit caused a large erosion in the

posterior wall of the duodenum, deeply penetrating the pancreas and producing chronic inflammatory disease of the head of the pancreas. The symptomatology here was produced both by the partial duodenal obstruction and by the pancreatic penetration. A diagnosis of pit was made from the x-ray findings.

Case 2 demonstrates another feature seen when fruit pits are arrested by duodenal obstruction, e. g., that the relief of symptoms which occurs spontaneously may be due to the retrograde passage of the pit from the duodenum back through the pylorus into the stomach. The diagnosis was not made preoperatively in this instance, although it should have been suspected from the shape of the mobile defect.

The x-ray features of pit obstruction have been described elsewhere, but certain factors should be emphasized. The filling defects produced by pits are elliptical and outlined by barium. Their radiolucent centers are traversed by fine concentric elliptical lines.

Surgical therapy in duodenal pit obstructions must be directed toward removal of the foreign body and toward treatment of the fundamental lesion. The pit usually can be removed with ease through a small incision in the stomach. This is preferable to a duodenotomy because it does not pose any additional problem in the duodenal closure should gastric resection be chosen for the treatment of the duodenal ulcer. In both patients reported, the local duodenal pathology made gastrectomy a hazardous procedure and dictated elective gastroenterostomy with vagisection as the therapeutic operation.

SUMMARY

Two cases are presented wherein chronic duodenal obstruction was due to the impaction of ingested fruit pits in an area of duodenal stenosis resulting from chronic peptic ulcer. The increased danger of such obstructions at other areas of disease and at surgical anastomosis sites is stressed. The pit may become impacted between the pylorus and stenotic zone or may move freely back and forth from the duodenum to the stomach. Both situations were illustrated by the patients reviewed.

The symptomatology is bizarre, and the diagnosis is made only with difficulty unless the history is specifically elicited and/or elliptical shadows with inner concentric striations are diligently sought in the barium meal study. It is noted that both patients, rather than displaying symptoms of chronic intestinal obstruction, exhibited complaints suggestive of exacerbation of ulcer.

Treatment consists of extraction of the pit through a gastrotomy and, for treatment of the ulcer, gastroenterostomy with vagisection rather than gastric resection, since the local duodenal pathology in most instances renders gastrectomy a hazardous procedure.

Permission to report the first case was granted by Dr. Leon Ginzburg, New York.

Femoral Artery Embolectomy

Report of Six Cases

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and
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Peripheral artery embolization, while relatively uncommon, is a medical and surgical emergency in which time is of the essence. The difference between prompt action and unnecessary delay may mean the saving of a limb instead of a needless amputation. Therefore, although peripheral emboli are relatively uncommon, it is essential that every physician and surgeon keep continuously mindful of the condition and its proper handling. The role of the family physician who first sees such a patient is obviously paramount.

Multiple embolism is not rare, but sucessful removal of successive emboli from the same vessel has not often been reported. McGarrity and Robinson [1] report three embolectomies in a 42-year-old woman, one in the left femoral artery and two in the right common femoral artery.

Scott and Williams [2] have reported three embolectomies in one young man suffering from subacute bacterial endocarditis. Two of these were lodgments at the left common femoral artery.

The following six consecutive cases are presented with these facts in mind.

REPORT OF CASES

CASE 1.—*Femoral Artery Embolectomy*

This was the first Meadowbrook Hospital admission for a 79-year-old man admitted Nov. 11, 1953, for the treatment of bronchopneumonia and congestive heart failure. Five months prior to admission the patient had a cerebrovascular accident leaving a residual disorientation for past events. On physical examination the patient was found to have a blood pressure of 120/60, bilateral bronchopneumonia, auricular fibrillation at a rate of 56 per minute, and congestive heart failure. He was treated with penicillin, digitalis, and mercurials. On Nov. 13, 1953, two days after admission, he was awakened at 1 a. m. by severe pain in the left thigh. Two hours later there was diminished sensation in the left lower leg, and there was a line of demarcation 5 in. below the inguinal ligament, with a cold, mottled leg distal to this. The medical resident made the diagnosis and called the surgical service immediately. Femoral pulses were palpable bilaterally, the right femoral 12 cm. below the inguinal ligament and the left 5 cm. below, at which point there was tenderness. Popliteal and dorsalis pedis pulses were present only in the right leg. Reflex heat was instituted by applying hot water bottles to the abdomen and both arms. After 30 minutes of this treatment the left leg showed little improvement. The patient was taken to the operating room four hours after the onset of symptoms, and the left common femoral, profunda, and superficial femoral arteries were exposed under local anesthesia. A pulsation was noted in the femoral artery above the profunda, but there was an abrupt cessation of pulsation 1 cm. above the bifurcation; the wall of the common femoral artery was good, but the superficial femoral artery was sclerotic. A 1 cm. long vertical incision was made on the anterior surface of the common femoral artery. With forceps the embolus was extracted with a red clot attached measuring 26 cm. in length. The arterial wall was closed with a running fine nonabsorbable surgical (silk) suture through the adventitia, which had not been removed. The wound was infiltrated with 1,000,000 units of aqueous penicillin, and 100 mg. of heparin was injected into the artery. The skin of the left leg and foot were noted to be warm and normal in color immediately after operation. The patient was continued on anticoagulants and walked on the first postoperative day. The dorsalis pedis artery could not be palpated on the left leg until the second postoperative day, but it remained palpable thereafter. Convalescence was uneventful.

CASE 2.—*Femoral Artery Embolectomy*

A 76-year-old man was admitted to Meadowbrook Hospital on Nov. 20, 1953, because of lobar pneumonia. He was found to be in congestive heart failure

Submitted for publication July 15, 1955.

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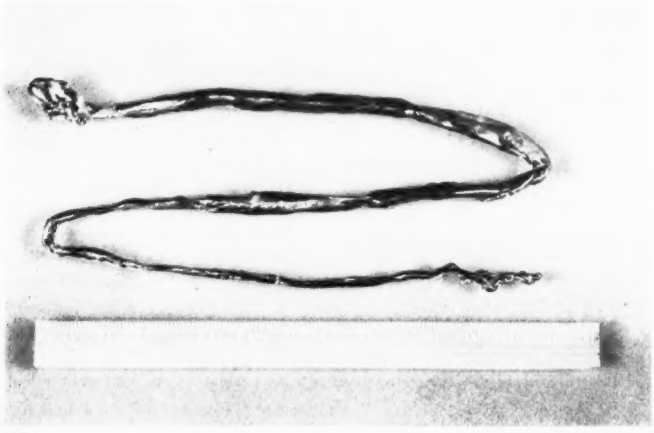
and to have auricular fibrillation. Treatment consisted of antibiotics, digitalis, and mercurials. On the 10th day of hospitalization he complained of pain in the left foot and left leg. The pain persisted throughout the next 10 hours, at which time the surgical service was called. It was noted that the toes and plantar surface of the left foot were cold and cyanotic. There was also coolness of the left calf. The foot was free of motor impairment, but there was impaired sensation from the left knee down. Popliteal and dorsalis pedis pulsations were present on the right but not on the left. There was also point tenderness and a disappearing pulse 6 cm. below the left inguinal ligament. The impression at this time was that the patient would lose his left foot, but, since the changes present were still reversible, arteriotomy was considered to be worth while. The patient was taken to the operating room 16 hours after the onset, and under local anesthesia the common femoral, profunda, and superficial femoral arteries were exposed. Pulsation stopped abruptly at the level of the bifurcation. Arteriotomy was performed in the common femoral artery 2 cm. above the bifurcation. A free flow of blood was obtained from above but none from below. A clot was extracted from the distal vessel, but no free flow of blood occurred. Finally, a glass suction tip was inserted into the artery below, and a red-tailed clot 50 cm. in length was removed after vigorous suction (Fig.). The artery was closed with silk sutures after 50 mg. of heparin was injected into the vessel. The wound was not drained. A good dorsalis pedis pulse was palpated in the left foot immediately. The patient was ambulatory on the first postoperative day, and anticoagulants were continued. He was discharged on the 18th postoperative day with a good dorsalis pedis pulsation and a normal warm extremity; his heart was still fibrillating.

CASE 3.—*Recurrent Femoral Artery Embolization.*

On Dec. 9, 1953, a 58-year-old woman was admitted to Meadowbrook Hospital. This was the third admission for this patient, who had previously been treated for an embolus to the left brachial artery, rheumatic heart disease, and auricular fibrillation. On this admission the patient complained of pain in the right leg of four hours' duration. Physical examination revealed a blood pressure of 150/80, pulse grossly irregular at a rate of 110 per minute, and a cold right leg from mid thigh distally, which was blanched in appearance. There were no palpable pulses below the common femoral in the right leg, and the dorsalis pedis could be palpated on the left. With local anesthesia the right common femoral artery was exposed and opened and the embolus was removed. The vessels were tested for patency, and the incision was repaired with a continuous 000000 silk suture. A pulse was present in the right dorsalis pedis artery postoperatively. She was maintained on digitalis and anticoagulants and was discharged after three weeks with a functioning, warm right leg, but the heart was still fibrillating. Six weeks after discharge at 9:30 p. m., while sitting at home with her daughter, the patient suddenly developed numbness in the right leg. She told her daughter, "this is the same as the last time. Please take me to the hospital." Physical examination revealed an acutely ill woman sitting upright in an oxygen tent, fibrillating at the rate of 140 per minute. There was no palpable arterial pulsation below the common femoral artery on the right side, and the leg was cool, moist, and dusky. She was treated for her congestive heart failure and six hours after the onset of symptoms was taken to the operating room. Under local infiltration of procaine hydrochloride (Novocain) the right femoral artery was exposed



Case 2.—Sixteen hours after an embolus was thrown to the left common femoral artery, a 50 cm. red-tailed clot, as well as the embolus (upper left-hand corner), was removed.

through a vertical incision with the patient sitting in a high Fowler's position. The site of previous arteriotomy was noted and left intact. Pulsations stopped abruptly at this point. A vertical incision was made in the artery just above the previous incision, and three small clots (each measuring from 0.5 to 1 cm.) were removed from the lumen of the vessel. There was no extension of the clot, and the vessels beyond were patent. The vessel wall and incision were closed in the usual manner, and the wound was drained. The patient was started on anticoagulants. Twenty-four hours postoperatively it was necessary to return her to the operating room to evacuate a large hematoma which had developed gradually and occluded the arterial circulation. She was maintained on anticoagulants and gradually ambulated. An unsuccessful attempt was made to revert the auricular fibrillation with quinidine. She was discharged after three weeks with a good dorsalis pedis pulse, a warm functioning limb, and still fibrillating.

CASE 4.—*Femoral Artery Embolectomy*

A 53-year-old man was admitted to Meadowbrook Hospital on July 14, 1954, because of marked dyspnea. He was found to be in congestive heart failure and to have auricular fibrillation. The patient had a history of rheumatic fever 17 years previously and episodes of congestive heart failure during the past 7 years. Admission blood pressure was 220/140, and the pulse was 152 and irregular. There were rales in both lung bases, and the liver was down to the crest of the ileum. There was a pitting edema of both ankles, and the dorsalis pedis pulsation was palpable bilaterally. Six days after admission the patient complained of sudden pain in the right foot and calf, with inability to move the right foot. The femoral artery was palpated at Poupart's ligament. The leg was cold and mottled to a level 3 in. above the knee. The medical service was reluctant to allow embolectomy because of the patient's poor general condition. However, it was believed by the surgical service that conservative measures would probably result in the loss of the right leg and that an operation under local anesthesia would not adversely influence his general condition. Therefore, on July 20, 1954, four hours after the onset of pain, a right femoral artery embolectomy was performed. A clot 6 cm. in length was removed from the common femoral artery at the bifurcation of the profunda. The dorsalis pedis pulsation was present in the right leg postoperatively, as was normal motor function. Postoperatively he was continued on digitalis and started on anticoagulant therapy as well as antibiotics. Ambulation was started the morning after operation. On the 10th postoperative day the auricular fibrillation was reverted to a normal rhythm with quinidine. Several days later the patient again demonstrated auricular fibrillation and, he was transferred to the medical service for further care. His condition worsened; he became more and more dyspneic, and his blood pressure fell. He did not respond to therapy and died on Aug. 25, 1954. At autopsy gross cardiac hypertrophy and a recent myocardial infarction, as well as a purulent pericardial effusion, was found.

CASE 5.—*External Iliac Embolectomy*

A 64-year-old hypertensive woman was admitted on July 19, 1954, with arteriosclerotic cardiovascular disease and known fibrillation for the previous five years. One hour prior to admission she noted sudden pain in her left leg. Physical examination showed the following findings: blood pressure 230/110, pulse rate 84 and irregular, no palpable pulse in the left leg, and only the femoral artery pulsation present in the right leg. Motor function was lost in the left leg. Operation was performed under local anesthesia. The common femoral artery was exposed and opened. It was interesting to note that this patient apparently had an absent left profunda femoral artery. An adherent red blood clot was present at this point. With the aid of a glass suction tube the clot above was broken up and removed. Much of the clot was broken up digitally with gentle pressure on the outer wall of the artery. Part of the clot was removed from the vessel 8 cm. above the inguinal ligament. Finally, a free flow of blood was obtained from above. In similar fashion, a part of the clot was removed from the artery distally. However, since all the clot could not be removed, it was elected to open the left posterior tibial artery. No free blood flow was present here, and so the posterior tibial artery was irrigated with heparinized saline, as suggested by McGarrity and Robinson.[1] The incision in the femoral artery was closed, and a free flow of blood was then obtained from the posterior tibial artery. Postoperatively there was a return of normal color, temperature, and motor function. Ambulation was started on the first postoperative day, and anticoagulants were given. The left foot and lower leg were slightly cooler than the right at the time of discharge, but a good functional result was apparent.

CASE 6.—*Femoral Artery Embolectomy*

The patient was a 62-year-old woman admitted to Meadowbrook Hospital on Aug. 16, 1954, with a 13-hour history of pain and coldness in the right leg. The pain and coldness were superseded by a "pins and needles" sensation. She also gave a history of transient substernal pain 12 days before admission. She had had rheumatic fever as a child and gave a history of auricular fibrillation during the past 20 years. On admission physical examination the patient was noted to be markedly obese. Blood pressure was 160/80, and the pulse rate was 78. The heart was found to be enlarged to the left, with a completely irregular rhythm. The right leg was found to be cooler than the left. The femoral pulse was palpated for 13 cm. below the left in-

guinal ligament, but it could not be palpated below the right inguinal ligament. The left dorsalis pedis pulsation could be palpated but not the right. The nails on both feet were normal in appearance, and the distribution of hair was normal. Admission laboratory work was normal. EKG confirmed auricular fibrillation. The patient was taken to the operating room five hours after admission, and embolectomy was performed under local procaine hydrochloride anesthesia. The vessels were exposed in the routine manner, and a 1 cm. long clot was removed from the common femoral artery at the bifurcation. The vessel was closed with 000000 continuous silk sutures and immediately after operation a right dorsalis pedis pulsation was noted. Heparin was started immediately, as well as bishydroxycoumarin (Dicumarol). Four hours postoperatively it was necessary to evacuate a hematoma and neutralize the heparin with protamine. Bishydroxycourmarin was continued, however, and the patient had an otherwise uneventful recovery, being discharged two weeks postoperatively with a good functioning right lower extremity and a palpable dorsalis pedis pulse on the right.

COMMENT

General Considerations.—Emboli usually lodge at arterial bifurcations, where there is a sudden diminution in the diameter of the lumen. In the lower extremity more than 50% of the arterial emboli lodge in the femoral artery at the origin of the profunda femoris. Seventeen per cent of the emboli occur at the bifurcation of the common iliac, and five per cent lodge at the bifurcation of the aorta. Twelve per cent of the arterial emboli are present in the upper extremity. Lund,[8] however, advocates conservative management of these, since embolization to the upper extremity seldom leads to gangrene. In more than 95% of the cases arterial emboli come from the heart, either from a mural thrombus resulting from a myocardial infarction or from a thrombus present on a fibrillating auricular appendage.[4]

Differential Diagnosis.—Haimovici[5] reported a series of 330 cases with the following findings: a sudden onset of pain was noted by 60% of the patients, and 22% had sudden numbness and coldness without initial pain. A gradual development of pain was noted by 8%, and 4% had gradually developing numbness and coldness. In 6% of cases the arterial occlusion was apparently silent. The initial site of pain seemed to be in the region of lodgment of the embolus. Numbness, coldness, and tingling usually appeared after pain.

Arterial embolism must be differentiated from thrombosis. A history of occlusive peripheral disease, lack of hair on the extremities, thickened nails, and bilateral absence of pulses helps in the diagnosis of thrombosis. In doubtful cases it is probably better to explore. Acute thrombophlebitis of the deep veins of an extremity may throw the arteries into severe spasm, occasionally causing the palpable pulses to disappear. Inspection for venous engorgement and the use of the oscillometer to detect a pulse in the calf will aid in making this differential diagnosis. Reflex heat or paravertebral blocks may aid in the differential diagnosis.

Localization of the level of the embolus is facilitated by the level of temperature and color changes. Popliteal emboli will cause temperature and color changes to the ankle or a little above. Femoral emboli will cause changes to the lower thigh; iliac emboli, to the groin, and aortic or saddle emboli will of course show bilateral change.

In emboli lodged at the common femoral bifurcation, we have been impressed with the usefulness of one sign in particular. This is the fact that on the normal side one may palpate the femoral pulse some 10 to 14 cm. below the inguinal ligament, whereas on the involved side the pulse may be felt to end suddenly just below Poupart's ligament. We have also noted, as have others, that there is tenderness here at the level of the embolus.

Operation vs. Conservative Management.—Age is certainly no contraindication per se, as is borne out by our three 75-year-old patients. Nor can we assume that advanced age necessarily means atheromatous arteries. In Case 1 we see an example of the patchy distribution of atheromatous change. Only by exploration can the condition of the vessel be determined.

If femoral artery embolization is left untreated, 29% of these limbs will survive.[6] If intensive conservative management is utilized, i. e., pavaex boot or intermittent venous

occlusion, oscillating bed, papaverine, and paravertebral blocks, then 60.5% of these limbs will survive.[6] McGarrity quotes Linton as saving 86% of limbs with surgery and 66% with conservatism. In a more recent series in which 48% of the presenting cases had femoral embolectomies, there was an 83.3% limb survival rate for surgical, as opposed to 88.5% rate for the nonsurgical, treatment. The good results obtained by both means of management were attributed to the earlier referral of patients to the hospital with the resulting wider option on the part of the physicians to select the proper type of treatment.[9] Even more important than this, however, is the fact that good anatomical function results in 50% to 60% of those treated surgically and that only 25% to 30% of those treated conservatively have a satisfactory limb.[5]

Importance of Early Operation. — After embolization occurs and the blood clot lodges, propagation of the clot distalward is a frequent occurrence. The vessel may go into spasm. Both of these factors result in ischemia which may be irreversible after 6 to 10 hours. Best results are to be expected when the embolectomy is performed within the first 10 hours, but after 24 hours have passed Pearse [7] has still obtained an 8% good result. Surgery should not be abandoned because of any set deadline; the determining factor in late embolectomy should be the appearance of the involved limb.

Operative Technique.—In the younger age groups vasospasm may be a major problem; consequently, gentleness in the handling of the femoral artery is indicated. We believe that almost all emboli to the lower extremities may be approached through the femoral artery. Both popliteal and saddle emboli can be confirmed through the femoral approach. Local anesthesia may be used satisfactorily in all cases. A vertical incision is made over the femoral artery below the inguinal ligament, and this incision may be extended in either direction. The femoral vein is separated from the artery with care, the site of obstruction is obvious, and it is not necessary to strip the adventitia. Soft rubber catheters may be placed about the femoral artery above and below the site of embolization. A third catheter is placed around the profunda. The vessel is opened through a longitudinal incision, and the clot is removed. Special care should be exercised in the removal of the emboli so that if there is fragmentation none will pass distally. A free flow of blood should be obtained from each of the three directions. If secondary thrombosis has occurred, it may be necessary to pass a suction tip or silver wire corkscrew down the vessel to remove the clot. In addition to removal of the embolus, it is important to restore the lumen of the vessel as far distally as possible. McGarrity and Robertson [1] suggest irrigation of the posterior tibial artery with heparinized saline if there is difficulty in removing the propagated thrombosis from above. The vessel is closed with a fine continuous Atraumatic silk suture. The incision may be drained if hemostasis has been unsatisfactory. Anticoagulants may be started immediately.

The treatment of emboli above the femoral artery is divided into two schools. Linton [6] and others advocate a direct approach to the embolus, either transabdominal or retroperitoneal. On the other hand, there are surgeons, such as Pratt and Smithwick, who favor opening the femoral artery and attempting to either "milk" the embolus down manually or to "break it up" by instrumentation from below. Pratt [4] utilizes milking, catheter suction, and especially the employment of a "corkscrew" passed retrograde through a catheter. The corkscrew is made by wrapping wire about a surgical probe. The corkscrew is inserted in a rubber catheter which is passed up the artery until it meets the clot. The corkscrew, which up to that time is entirely within the catheter to protect the vessel wall, is now pushed beyond the catheter and rotated into the embolus, and an attempt is made at extraction, piecemeal if necessary. In our experience, by far the most useful instrument has been a simple glass suction tube of small caliber.

Postoperative Management. — Both legs are wrapped in sheet wadding after the oper-

ation. A cradle is placed over the foot of the bed. Anticoagulants are given to prevent thrombus formation in the operated vessel, and this is maintained for three weeks. If the patient has auricular fibrillation, then anticoagulants should be maintained even after the patient is discharged from the hospital, perhaps for the duration of life. Ambulation is started as early as is deemed advisable, and this has usually been well within the first 24 hours.

SUMMARY

Peripheral artery embolization is a medical-surgical emergency which requires immediate diagnosis and treatment.

Six cases are presented to demonstrate the principles of diagnosis and management. One of these is a case of recurrent femoral artery embolization.

In the lower extremity more than 50% of the arterial emboli lodge in the femoral artery, at the origin of the profunda femoris. The clinical picture is characterized by the sudden onset of coldness, pain, and numbness of the leg. The differential diagnosis lies between embolism, thrombosis, and thrombophlebitis. Good anatomical function results in 50% to 60% of those treated surgically and should approach 100%. Of those managed conservatively only 20% to 25% have satisfactory anatomic function.

The best results are obtained when embolectomy is performed within the first 10 hours. At the time of operation it is important to restore luminal patency. Anticoagulants and supportive measures are utilized postoperatively, and long-term anticoagulant therapy should be strongly considered in each patient with chronic fibrillation.

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Pedal Anomaly

Report of a Case

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Duplication of a lower extremity, and more especially of a foot, has been reported infrequently and at wide intervals in the medical literature. Smook [1] reported a case of hyperdactylia which, when examined more closely, was apparently an embryonic attempt at double foot formation. Gould and Pyle [2] cited the case of a female infant with a cloven or double foot, and Mayer and Sashin [3] reported a genuine double foot, the components of which were joined side-by-side and which was treated successfully by surgical operation. Another author [4] presented a series of several severely deformed fetuses having doubly formed extremities.

We submit the following case report concerning a pedal anomaly the exact nature of which apparently is unique or has never been recorded in the medical literature.

Submitted for publication Sept. 3, 1955.

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REPORT OF A CASE

A man 53 years of age first registered at the clinic for diagnosis and treatment of episodes of headache and syncope. On routine examination his unusual foot structure was discovered. Although there was normal skeletal structure otherwise, he had a tarsal configuration and foot structure on the left composed of one outwardly normal foot and a supernumerary or rudimentary foot—or, preferably, a "double foot."

When questioned, the patient stated that the foot structure was unmodified from its congenital condition, except for a minor operation. (About 12 years previously, a calloused area had been removed.) The foot had required a specially padded shoe but never had led to any marked disability. He had participated actively in basketball at college and now was able to perform a busy routine as a minister. He experienced no real discomfort, and he walked with only a slight limp.

Fig. 1.—Photograph of the "double foot." The dorsal component has five toes, including a well-defined great toe, whereas the plantar component has only three toes.

Fig. 2.—Photograph of the entire left extremity showing the web across the popliteal space. The photograph was made with the knee in flexion to demonstrate the web. Active extension to 180 degrees could be accomplished easily.

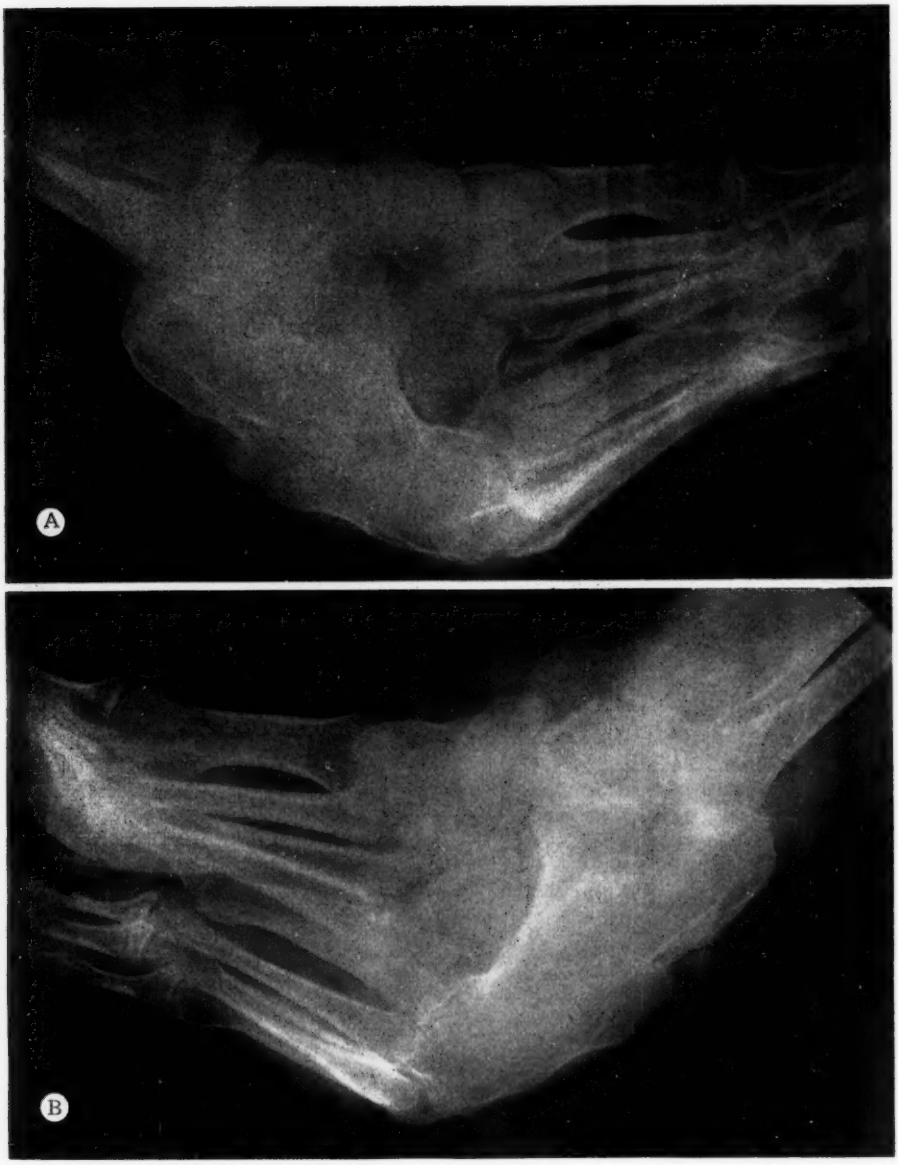

Fig. 3.—Roentgenographic views of the anomaly. *A*, roentgenographic view from medial aspect. *B*, roentgenographic view from lateral aspect. *C*, roentgenographic view from dorsal aspect. *D*, roentgenographic view with the foot slightly inverted.

At orthopedic examination the patient was found to have a double foot, the two component parts joined in sole-to-sole fashion, with the uppermost, or superior, foot having five toes, and the lowermost, inferior or plantar, foot having three toes. The dorsum of the inferior foot was the weight-bearing surface. The entire structure was an equinus type of deformity, with both feet arising from a talus and os calcis. There were multiple calloused areas over the weight-bearing locations, and considerable atrophy existed in the muscles of the lower leg.

An interesting anomalous condition existed consisting of a fleshy web across the popliteal space. This web would contract on flexion and apparently represented accessory fibers of the gastrocnemius muscle, originating from the medial femur and inserting into the heel cord. The web did not limit the range of motion of the knee joint, for complete extension was possible. Pulsation was not felt in this web. The deformed extremity was just a little shorter than the normal right extremity.

Roentgenograms of the foot were taken from several angles, and a bizarre tarsal structure with almost normal but excessive metatarsal and phalangeal components was revealed. Accurate definition of the various components, as seen on the roentgenograms, is very difficult and will be at-

tempted only for the sake of interest. The bases of the eight metatarsals were modified to form articulating surfaces with the abnormal tarsal bones. The tarsal complex consisted of five bones: (1) an os calcis, which most certainly had a total mass in excess of normal. It articulated with what appeared to be the talus and with another bone in the distal tarsal row, to be described. The three metatarsals of the inferior foot articulated with the most distal extent of this os calcis; (2) a talus, somewhat less in mass than the normal, articulated with the tibia, the aforementioned os calcis, and (3) a navicular. This navicular was about normal in size and articulated with the talus and with a bone which was apparently a combination of (4) the cuneiforms. It would seem most likely that this fourth bone represented a fusion of the first and second cuneiforms and possibly the third cuneiform if one judges by the expected articulating surfaces offered by the metatarsals. The first, second, and third metatarsals articulated with this bone, as well as with the navicular and the next component. The fifth tarsal bone is the (5) cuboid or possibly a fusion of the third cuneiform and the cuboid. The third, fourth, and fifth metatarsals articulated with the last bone, as do all the other tarsal bones except the talus.

EMBRYOLOGY

Pure conjecture is the only avenue for safe discussion of the origin of this anomaly. Some authorities might attribute its occurrence to mechanical action of amniotic adhesions. Most embryologists now would agree, however, that such an occurrence is primarily an intrinsic abnormality of the tissues, and any adhesions found in association represent a sequela of the anomaly. We may theorize that the unsegmented somatic mesoderm which pushes outward into the newly formed limb bud, and from which the axial skeleton develops, became abnormally condensed and subsequently led to abnormal ossification centers. Such abnormal condensation may occur at any stage in the development of a limb, if one adheres to the well-supported premise that, as the limb bud develops and its various parts are determined in the tissues, new, intricate, equipotential symptoms evolve for smaller parts such as the foot and the digit. Noteworthy theories have been advanced that the single embryonic limb bud has an inherent tendency toward duplication, which is repressed normally.* As a matter of record, duplication of the entire extremity, or a large protion thereof, has been produced repeatedly by embryologic transplant experiments, and several authors have concluded that polydactylia, a rather common condition, is an expression of reduplication of the limb.†

We do not propose to discuss the concept of tarsal fusion, since the configuration is so unusual. It is sufficient to state that case reports of cuneiform fusions have been cited by Sloane [6] and Lapidus,[7] but there is no available record of fusion of the second cuneiform with the third cuneiform. Cuboid-cuneiform fusions, covering all possibilities, have been reported by Chambers.[8]

PROPOSED CORRECTIVE MEASURES

Since the patient desired no corrective measures for his pedal anomaly because of his age and his freedom from marked disability, he was dismissed when his clinical examination was completed. Had the patient presented himself earlier, surgical reconstruction probably would have been advocated. This procedure would have required removal of the plantar foot with preservation of the weight-bearing skin plus mid-dorsal osteotomy and arthrodesis of the upper joints.

SUMMARY

A case report concerning a patient having a very unique pedal anomaly is presented. This man, with skeletal structure otherwise normal, had tarsal configuration and foot structure on the left composed of one outwardly normal foot and a supernumerary or rudimentary foot—or, preferably, a "double foot." Speculative approaches to definition of the exact structures and embryological explanation of these structures are advanced, and proposed corrective measures are discussed.

* Brandt, W., and Swett, F. H., cited by Gruenwald.[5]

† Gabriel, M. L., cited by Gruenwald.[5]

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Acute Intermittent Porphyria with Acute Abdominal Findings and Palpable Mass

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Acute intermittent porphyria may simulate acute appendicitis, acute cholecystitis, bowel obstruction, and other acute abdominal conditions. The following case is reported to emphasize that acute intermittent porphyria may be responsible for the clinical picture of an acute surgical abdomen and that it may even lead to the development of a palpable abdominal mass following roentgenographic barium studies.

REPORT OF A CASE

A 40-year-old white woman entered the hospital on Aug. 17, 1954, complaining of severe constant low-back boring pain and lower abdominal sharp crampy pain which had been present for approximately one month prior to admission.

Present Illness.—The patient, who had apparently been well until July 18, 1954, had at that time a three-day episode of diarrhea. She recovered from this but, at approximately the end of July, noticed the onset of very severe low-back pain in the upper sacral area. She had mild anorexia in conjunction with this pain but did not vomit. Since her pain became worse, she was admitted to a hospital in her home town, where numerous studies, including upper gastrointestinal and barium enema x-ray examinations were carried out. From Aug. 5 until the day of admission, she had to have an enema every other day in order to have a bowel movement and on several occasions was nauseated and vomited. About Aug. 11, she developed constant aching in the lower abdomen and found that the pain was unaffected by position or eating. On Aug. 13, abdominal examination with general anesthesia, dilation and curettage, and conization of the cervix was carried out. During her stay in the local hospital, she vomited on several occasions, her temperature was normal or slightly increased, and, at times, she was confused and talked incoherently.

Past History.—In 1948, the patient had an appendectomy and a "tightening of her tubes." In the same year, during her second pregnancy, she had a convulsion and, after the pregnancy, had "nephritis" and "uremia."

Physical Examination.—On the day of admission to University Hospital the patient appeared to be a fairly well-developed, rather thin, white middle-aged woman who appeared her stated age and who appeared chronically ill. Her temperature was 98.2 F; pulse rate, 108; respirations, 18, and blood pressure, 154/84. The abdomen was flat and not distended and was slightly tender in the lower half. It did not exhibit rebound tenderness nor a palpable mass but did present slightly hyperactive, normally pitched, peristaltic sounds. The vaginal and rectal examinations were not remarkable. The remainder of the general physical examination was essentially normal. The neurological examination was entirely negative.

Laboratory Data.—At the time of admission, the erythrocyte count was 4,300,000; the hemoglobin level was 12.8 gm. per 100 cc., and the leucocyte count was 10,850, with 40% segmented neutrophiles and 17% nonsegmented neutrophiles, 35% lymphocytes, 2% eosinophiles, and 6% monocytes. Urinalysis indicated a specific gravity of 1.004, four to six white blood cells per high-power field, and a pH of 6. The serum amylase determination was 49 Somogyi units; blood urea nitrogen, 16 mg. per 100 cc., and Wintrobe corrected sedimentation rate, 19 mm.

Hospital Course.—Numerous findings indicated the possibility of an acute surgical abdomen, in spite of the fact that the diagnosis of acute intermittent porphyria was established on the second hospital day. On the day of admission, the abdominal pain was severe enough to require the administration of 100 mg. of meperidine (Demerol) hydrochloride. Frequently, throughout the hospital stay, this amount of medication had to be repeated for the relief of pain.

Submitted for publication Aug. 5, 1955.

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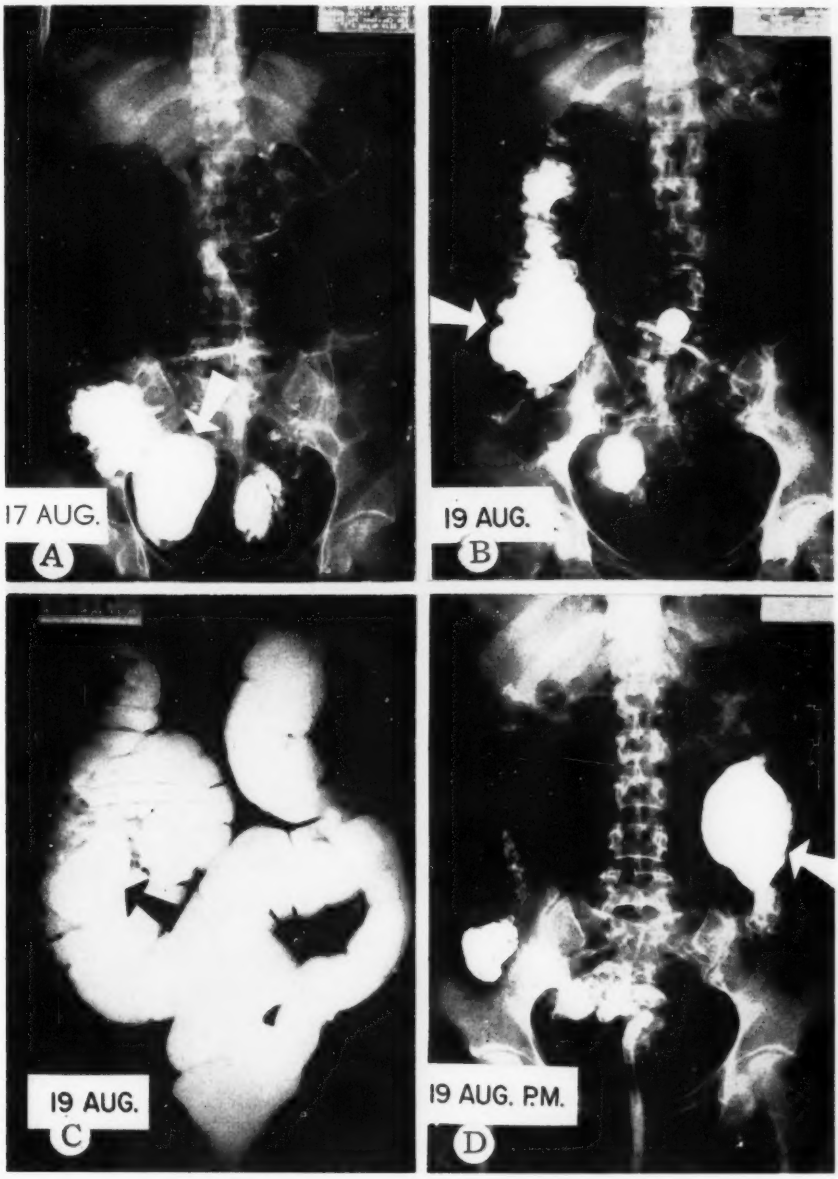

Abdominal roentgenograms showing the movement of a barium mass through the bowel in a case of acute intermittent porphyria. *A*, taken on day of admission to University Hospital after the patient had had upper gastrointestinal x-ray and barium enema examinations at another hospital prior to admission, shows the mass in the pelvis as well as gas in dilated bowel. *B* indicates the position of the object in the cecal area two days after admission. *C* suggested the possibility of the radiopaque object being in a diverticulum with a narrow neck at the time of barium enema x-ray examination; the mass is indicated by the arrow and appears to become narrower on its lateral aspect. *D* was taken after the mass had moved to the left transverse colon and could no longer be felt.

On the evening of admission, a recumbent anteroposterior abdominal roentgenogram (Fig. *A*) indicated an oval-shaped mass of barium in the right lower abdominal quadrant.

On the morning of Aug. 18, the diagnosis of porphyria was confirmed by urine tests, but a mass in the right lower quadrant was felt for the first time. It appeared to be 6 cm. in diameter, was firm, slightly tender, and freely movable, and seemed to lie within the peritoneal cavity rather than in the abdominal wall. On the same day, sigmoidoscopic examination to 25 cm. was not remarkable.

By the morning of Aug. 19, the diagnosis of acute intermittent porphyria had been further confirmed by several positive Watson-Schwarz and urine sunlight exposure tests. Barium enema x-ray examination (Figs. *B* and *C*), however, suggested the possibility of an intestinal diverticulum with a narrow neck and with barium trapped in the diverticulum. In addition, the total white blood cell count, as indicated by Table 1, had slowly risen from the admission value of 10,850 to 16,900, and the abdominal mass had persisted.

TABLE 1.—*Findings in a Case of Acute Intermittent Porphyria* *

Date, 1954	Abdominal Mass	Total White Blood Cell Count
8/17.....	Not palpable	10,850
8/18.....	Palpable	14,900
8/19, morning.....	Palpable	15,900
8/19, afternoon.....	Palpable	16,900
8/19, evening.....	Not palpable	.....

* After barium studies of the gastrointestinal tract, an abdominal mass was palpable. On Aug. 27 the barium mass was passed from the rectum.

Although the temperature was never higher than 99.6 F, the pulse rate had risen to 120, and colicky abdominal pain persisted. It was believed, therefore, that, regardless of the diagnosis of acute intermittent porphyria, an exploratory laparotomy was indicated to rule out the possibility of a twisted intraperitoneal viscus or gangrenous bowel.

Just before the patient was taken to the operating room, the mass was easily felt in the right lower abdominal quadrant. As the anesthetic was to be administered, the abdomen was again examined and the mass was no longer palpable.

An anteroposterior roentgenogram (Fig. *D*) which was taken immediately indicated that the barium mass had moved to the left transverse colon. A conservative medical regimen was elected, and the patient was given multiple enemas and a variety of strong cathartics. On the morning of Aug. 27, the patient passed the barium spontaneously. From then on until her discharge on Aug. 30, the hospital course was not remarkable.

Spectrophotometric studies of extracts of urine specimens obtained on Aug. 18 and Aug. 23, 1954, demonstrated pathological concentrations of coproporphyrins and/or uroporphyrins.

Final diagnoses were the following: (1) porphyria, acute, toxic (intermittent); (2) barium conglomerate in colon; (3) status after appendectomy, and (4) status after dilation and curettage.

COMMENT

As Watson [1] points out, porphyria has been generally used to denote the peculiar constitutional inborn error of porphyrin metabolism characterized by marked reproduction of uroporphyrin and related substances. There is some uncertainty as to whether such overproduction always represents a constitutional disturbance or whether in rare instances it may appear as a sequel to some other disease, such as an infectious or toxic state.

The porphyrins [2] are constituents and break-down products of such substances as myoglobin, hemoglobin, and chlorophyll. All of these are concerned with cellular respirations. Under normal conditions certain porphyrin compounds are formed during hemoglobin synthesis and are constantly excreted in small amounts. In porphyria, however, there is some interruption in the cycle of hemoglobin synthesis or breakdown. The result is an accumulation in the body and excretion in the urine of abnormal porphyrins.

Many years ago Gunther [3] described porphyria congenita, porphyria acuta, and porphyria chronica. More recently, however, Watson [1] has employed the following classifications: (*a*) photosensitive, (*b*) intermittent acute, and (*c*) mixed. The intermittent acute type which is seen by the surgeon exhibits acute abdominal and/or nervous manifestations. It appears in the third or fourth decade and is predominantly found in women.

Porphyria is not a frequently encountered and diagnosed disease. At the Ohio State University Hospital only 0.04% of cases admitted on the Medical Services in recent years, as seen in Table 2, have had porphyria.

TABLE 2.—*Incidence of Porphyria at Ohio State University Hospital* *

Cases admitted on Medical and Research Medical Services, University Hospital, Jan. 1, 1949, thru Dec. 31, 1954	18,486
Cases of porphyria	8
Incidence of porphyria, %	0.04
Cases of porphyria operated on for abdominal symptoms at University Hospital *	0

* No cases were subjected to laparotomy at University Hospital.

Patients with acute intermittent porphyria present a history compatible with any of a variety of abdominal surgical emergencies.* The abdominal pain is severe and is usually colicky. Usually when the surgeon sees the patient, the pain has been of only a short duration, but, after the diagnosis has been made, the pain may linger on for weeks. The appetite is poor, but there are no particular food idiosyncrasies. There may be only a history of vomiting, but very frequently there is a history of gradually increasing constipation over a period of days or even weeks. In many instances, a previous abdominal operation, such as an appendectomy, has been performed.

On physical examination, there are no findings specific for acute intermittent porphyria. Fever is unusual; the pulse may be elevated. The abdomen is usually soft and tender. Rebound tenderness is lacking. Peristaltic sounds are often hypoactive on account of the sluggish bowel, but they may be hyperactive if there are good peristaltic movements proximal to an area of fecal impaction. In most cases, the presently reported case being an exception, no mass is palpable. Vaginal and rectal examinations are not remarkable, except for a considerable amount of feces in the rectum.

Laboratory determinations, except the tests for the porphyrins, are not helpful in making a diagnosis of acute intermittent porphyria. Leucocytosis may be present in an acute attack.

The diagnosis of acute intermittent porphyria depends upon the demonstration of porphobilinogen or abnormal porphyrins in the urine by one of the four following methods: (1) the Watson-Schwartz test for urinary porphobilinogen,[7] (2) exposure of acid urine to sunlight,[2] (3) spectroscopic examination of the urine,[8] and (4) determination of melting point of urinary porphyrins.[6]

Roentgenographic studies of the gastrointestinal tract are of some value in indicating acute intermittent porphyria but do not definitely establish this diagnosis, since the disease does not produce a characteristic pattern.[9] Before administration of barium, there may be seen dilated loops of either small or large bowel proximal to an area of spasm. Abdominal x-ray films vary in appearance from day to day. A continuous dilated loop of intestine may appear in the upper half of the abdomen on one film and be replaced by a scattered pattern of dilated loops a few hours later. Short distended intestinal segments whose appearance changes on serial films are commonest. Fluid levels may be demonstrable. The colon, especially the cecum, may be dilated. The typical ladder pattern of mechanical obstruction is seldom seen. Barium enema may indicate a large dilated colon from which the barium is excreted very slowly. After the administration of barium by mouth, it may be noted that the passage of barium through the gastrointestinal tract is slower than normal and there may be demonstrated an area of spasm of the bowel.

Surgical intervention, of course, is not indicated in the treatment of uncomplicated acute intermittent porphyria. Nevertheless, the findings are so suggestive of acute surgical disease that very often these patients are subjected to laparotomy. In many of the reports in the literature † patients have had abdominal exploration with or without diagnosis of porphyria being suspected or established. Frequently, it may be impossible to rule out an acute condition within the abdomen by any means other than a laparotomy.

* References 1, 2, 4, 5, and 6.

† References 2, 4, 5 and 10-15.

There is no reason why both porphyria and a surgical condition cannot exist simultaneously; hence, occasionally it is wise to explore if the diagnosis of porphyria, once considered, cannot be substantiated. Chaput and Timmes [16] reported a case in which an adenocarcinoma of the descending colon was found in association with acute intermittent porphyria. Because of emphasis in the literature on colon spasm as a cause for abdominal symptoms in acute porphyria, radical surgical therapy was considerably delayed. In their report they point out that, in spite of the presence of the acute porphyria, their patient withstood laparotomy well.

SUMMARY

Acute intermittent porphyria may produce the clinical picture of an acute surgical abdomen, as indicated in the reported case.

After x-ray studies of the gastrointestinal tract of a patient with acute intermittent porphyria, a barium conglomerate may become palpable as a distinct tender abdominal mass.

Acute intermittent porphyria may occur simultaneously with an acute surgical emergency, as appendicitis, which, regardless of the porphyia, should be treated by operative intervention.

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Sympathectomy for Lower Extremity Occlusive Vascular Disease

Indications, Techniques, and Results

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As a result of modern preventive medicine and surgery the average life span has been increased to the point where geriatric problems are demanding more attention than was true in the previous medical generation. Peripheral vascular diseases assume major importance in this increasingly aged general population.

The sympathetic nervous system plays a vital role in the pathogenesis as well as the treatment of many peripheral vascular disorders. In certain diseases much of the etiology can be traced to increased sympathetic activity, viz., Raynaud's disease, causalgia, frostbite, reflex sympathetic dystrophy, and, to a more limited extent, the postphlebitic syndrome.[1] In other instances the sympathetic system plays an important secondary role by setting up an extensive reflex vasoconstriction secondary to the stimulus of an occlusive arterial lesion. Such a situation obtains in peripheral arteriosclerosis and atherosclerosis as well as in thromboangiitis obliterans.

The sympathetic system functions as a defense mechanism in which a reflex vasoconstriction occurs in response to a stimulus, usually some form of trauma. This trauma may be extrinsic in origin, such as a stab wound, gunshot wound, or contusion, or it may be intrinsic in nature, such as an intra-arterial plaque, clot, or calcium deposit on the intima. Under these circumstances afferent stimuli are produced which reach the sympathetic ganglia, which, in turn, send out efferent stimuli to throw the vessel that originated the stimuli into spasm, together with other vessels in the adjacent area. Although the loosening of a large plaque or the lodgment of an embolus may obstruct the involved vessel, it is the accompanying spasm in neighbor vessels that may decide the life or death of the extremity. It is in such instances that interruption of the vasospastic reflex mechanisms by means of a sympathectomy is indicated and is, indeed, beneficial.

ANATOMIC CONSIDERATIONS

The sympathetic division of the autonomic nervous system arises from preganglionic cell bodies located in the intermediolateral cell column of the 12 thoracic and upper 3 or 4 lumbar segments of the spinal cord.[2] The postganglionic fibers which innervate the blood vessels, sweat glands, and smooth muscle of the skin of the lower extremities arise from the lumbar and sacral ganglia of the sympathetic chain.[3] In general, an attempt should be made to remove the sympathetic chain from the second lumbar to fourth lumbar ganglia, inclusive. Removal of the first lumbar ganglion, which supplies vasomotor and sudomotor sympathetic fibers to the area around the knee and thigh,[4] may be of value in some instances in the production of collateral vessels. If it is technically feasible, this ganglion should be removed. Since the first lumbar ganglion is usually

Submitted for publication July 29, 1955.

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partly covered by the diaphragm or embedded within the diaphragmatic crus, this is accomplished not without considerable difficulty.

PHYSIOLOGIC CONSIDERATIONS

In 1947 DeBakey and co-workers[5] indicated that the physiological principle of hemometakinesia is applicable to the management of peripheral vascular diseases. Briefly stated, this concept is as follows: The available blood volume in the body is fixed within certain limits. If more blood is required for one part of the body, some other part or parts of the body will be deprived of part of their blood supply. Thus, there is a "borrowing-lending" system of blood supply in the body economy. When an extremity is desympathectomized, more blood enters this limb and is drained from other parts of the body. For example, if the sympathetic nerves to the left lower extremity are interrupted, the left leg becomes warmer because of an increased blood supply; the right leg, however, becomes cooler. This is an important principle in the therapy of peripheral vascular disease, emphasizing as it does the fact that the most effective vasodilating therapy is confined to the local area of ischemia. If, however, a drug is used which induces a generalized dilatation of vascular tissue, peripheral ischemia may actually be aggravated as blood is drawn from everywhere to supply all parts of the body. Recently, Atlas[6] has applied the principle of hemometakinesia to the technique of lumbar sympathectomy, modifying the extent of removal of the lumbar sympathetic chain in each case of peripheral vascular disease to obtain a much more selective vasodilatation than the usual lumbar sympathectomy produces.

In bilateral lumbar sympathectomy where the first lumbar ganglion is removed bilaterally, the power of ejaculation may be lost with resulting sterility in about 30% of cases.[7] Other sexual characteristics, however, such as potency, are not changed. In some of the persons who have become sterile, the power of ejaculation may recur at a later date, possibly owing to reestablishment of sympathetic innervation or owing to some other levels taking over. In the female, no changes occur. To avert this complication in young subjects, one may weigh the advisability of removing L-1 only unilaterally.

It is generally agreed that the incidence of good results following sympathectomy is directly proportional to the completeness of removal of the sympathetic chain.[8] Where one is reasonably certain of adequate surgical extirpation of the sympathetic chain but denervation is less than was anticipated, regeneration of the sympathetic fibers has been incriminated. The great tendency for sympathetic fibers to regenerate and occasionally to cross even large defects to reinnervate an area is well recognized. Silver clips applied to the cut ends of the chain and rami have been advocated by those who believe that regeneration is a serious limitation of sympathectomy. When, however, there is recurrence of sympathetic activity soon after surgery, after an immediate postoperative period of denervation, it is very probable that the sympathectomy itself was incomplete and that some of the denervation was due to trauma to the sympathetic tissue without its actual excision.

There is some evidence that lack of complete denervation of sympathetic impulses to the thigh may be due to residual pathways through the anterior roots of T-12, L-1, L-2, and L-3.* Thus, in patients in whom the sympathetic chain had been removed in one piece from T-8 to L-3, so that L-1 was unquestionably a part of the specimen, sympathetic denervation of the thigh gradually disappeared so that by the 10th postoperative day sympathetic impulses to the thigh were virtually at a preoperative level. Further experimentation has localized this recurrent sympathetic innervation to residual pathways emerging through the anterior roots of T-12, L-1, L-2, and L-3 and not traveling along sympathetic pathways. Thus, it is virtually

* Console, A. D.: Personal communication to the author.

impossible to obtain complete sympathetic denervation of the thigh area unless one does a laminectomy with an intraspinal division of the anterior spinal roots from T-12 to L-3.

CLINICAL USE OF LUMBAR SYMPATHECTOMY

As previously mentioned, interruption of the sympathetic system plays a major role in the treatment of those peripheral vascular diseases where overactivity of the sympathetic nervous system is the prime factor in the etiology, viz., Raynaud's disease, causalgia, and frostbite. Our concern in this paper is with the clinical applicability of lumbar sympathectomy in the occlusive peripheral vascular diseases, viz., thromboangiitis obliterans and arteriosclerotic endarteritis obliterans.

Thromboangiitis Obliterans.—The etiology of this entity is unknown. The disease occurs in young adults between 20 and 40 years of age, often Hebrew, Japanese, or Negro. Almost 99% of the reported cases are in males, and the lower extremities are involved in about 95% of the cases. Clinically, the disease is characterized by attacks of ischemia, pain, and numbness. Claudication in the calf or foot or thigh becomes progressively severe and is increased by effort and smoking. Sensory disturbances, including coldness, paresthesia, and anesthesia, are common. The rubor-pallor (R-P) sign is pathognomonic—on elevation the foot becomes very pale; on dependency it develops a marked redness. Most of the patients are heavy smokers, and nicotine has been proved to be an important initiating and causative factor. In those who have the underlying disease or a tendency to it, continued smoking will precipitate an attack, causing spasm in the collateral vessels and progression of the disease. Silbert [10] believes that the disease is produced by the use of tobacco in those persons who are sensitive to it. However, tobacco is ruled out as the sole factor by the development of this disease occasionally in a nonsmoker. An associated migrating thrombophlebitis occurs in about one-third of the patients. Pathologically, the disease process affects medium-sized arteries. During the acute phase there is an arteritis and periarteritis and frequently an accompanying phlebitis and periphlebitis. Only a segment of the vessel is involved, and thrombosis occurs in the inflamed segment with occlusion of the lumen. With the closure of the vessel there is usually some degree of spasm in the collateral vessels. In the chronic phase of the disease the thrombi have become organized into firm fibrous tissue, with some evidences of recanalization.

Arteriosclerotic Endarteritis Obliterans.—Evidence has accumulated to date indicating that diet and metabolism play a significant role in the etiology of this process. In atherosclerosis, certainly, cholesterol metabolism plays a major role in the pathogenesis. An important segment of patients with arteriosclerotic peripheral vascular disease are the diabetics. Apparently, as a result of abnormal fat metabolism, the peripheral vascular arteriosclerotic changes occur many years earlier in the diabetic than in other patients. Joslin [11] believes that all diabetics develop vascular sclerotic changes within 5 years after the development of the disease, although in young persons this may be somewhat modified by adequate diabetic control. The peripheral vascular problem is similar to that of the nondiabetic except that it appears at an earlier age, and when an infection develops it may spread very rapidly and become uncontrollable, like infection elsewhere in the diabetic. Because of infection as a serious threat in the diabetic, sympathectomy offers an additional advantage in management. Besides reducing reflex vasospasm in the collateral bed, it abolishes sweating in the denervated area. This prevents excessive moisture on the skin and especially between the toes of these patients, thereby averting areas of maceration which frequently act as portals of entry for organisms. Furthermore, the absence of sweating abolishes heat loss via this avenue, increasing the warmth of the extremity.

The selection of patients with occlusive peripheral vascular disease of the lower

extremities who will benefit by lumbar sympathectomy is a difficult task. Many tests have been devised to determine whether the sympathectomy will produce clinical improvement. The commonest of these is the determination of the rise in skin temperature of the extremity after a sympathetic block of the extremity. For this purpose paravertebral blocks are unsatisfactory because a poor elevation of the skin temperature after the block may be due to an incomplete block technically. For such tests, therefore, more precise information will be available if spinal anesthesia is induced to interrupt the sympathetic impulses. A very simple test which may be carried out as an office procedure and will provide information concerning the effect of sympathectomy on the circulation of the foot is the anesthetization of the posterior tibial nerve.[12] The nerve is easily palpated just below the internal malleolus behind the posterior tibial artery. The nerve is fixed in position with the index finger to prevent it from slipping to one side. Ten cubic centimeters of 1% procaine solution are introduced through the fascia surrounding the compartment in which the nerve courses. It is not necessary to actually infiltrate the nerve. Within 10 minutes, a sensation of heat radiating from the toes is noted if the patient has a normal circulation. Shortly thereafter, numbness and paresthesia in the sensory distribution (heel, sole, toes, and plantar surface of the toes) are noted along with motor weakness of the short flexors which occurs occasionally. The increased warmth limited to the anesthetized area is easily felt and stays at a high level for more than an hour, after which the anesthesia wears off and the surface temperature returns to the previous level. If there is impairment of the arterial circulation which is due to an occlusive arterial disease, anesthetization of the posterior tibial nerve causes a minimal response or none. If the impairment of the arterial circulation is due to arterial or arteriolar spasm, this procedure causes a sharp increase in the temperature of the skin simulating the response of persons who have normal circulation. If the impairment of arterial circulation is caused both by arterial occlusion and by spasm, there is an increase in the temperature of the skin, but this value does not reach maximal levels obtained with a normal circulation. To obtain precise skin temperature measurements with this test, it should be carried out in a controlled temperature room with sensitive skin-temperature-measuring instruments. Under such controlled conditions, the range of skin temperature for normal subjects in whom vasodilatation is produced is between 31.0 and 34.0 C.

There still exists some controversy as to the effect of sympathectomy on the blood supply to the muscle. Evidence against an important sympathetic constrictor innervation to skeletal muscle has been found by Abramson [13] and by Prinzmetal.[14] Abramson's evidence indicates that the increase in blood flow through an extremity following sympathectomy is almost exclusively due to increase in blood flow through the skin and that muscle blood flow is little affected. This work was done, however, on the resting extremity. There is no evidence available yet on the importance of the sympathetic nervous system in muscle blood supply during exercise, which is when the patient with peripheral vascular disease develops the pain of intermittent claudication. Clinically, there is statistical evidence to show that 30% to 70% of patients in various groups treated for arteriosclerotic or Buerger's peripheral vascular disease by lumbar sympathectomy have experienced relief or significant improvement in their claudication symptomatology.[9] Sometimes, it is necessary to wait 2 to 3 years after sympathectomy for increase in exercise tolerance.[15]

Recently, there have been numerous reports † attesting to the fact that benefit following sympathectomy has been noted even in those patients who showed a very poor temperature rise in the skin following a sympathetic block. For this reason, we recom-

† References 15 and 16.

mend a lumbar sympathectomy in all patients under the age of 55 who have occlusive peripheral vascular disease; we do not submit these patients to sympathetic block tests. For patients above the age of 55, in whom surgery becomes a greater hazard, a spinal anesthetic or posterior tibial block is recommended to determine the skin-temperature response. A lumbar sympathectomy is done only in those patients who show a good response.

TECHNICAL CONSIDERATIONS

Lumbar sympathectomy may be performed transperitoneally or retroperitoneally. In our hands the retroperitoneal technique has proved much simpler and more rapid. Even when a bilateral lumbar sympathectomy is planned at one sitting, the operation is completed with much less difficulty through two separate incisions via the retroperitoneal route than through a single incision employing the transperitoneal avenue.

Transperitoneal Approach.—Either a rectus retracting or splitting incision may be used, periumbilical, about 4 in. long. The patient is placed in Trendelenburg position to help pack off the intestines. All the small bowel and its mesentery should be elevated with warm packs. The rubber bag described by Lahey [17] into which the entire small intestine may be eviscerated serves admirably to gain good exposure. The cecum and sigmoid are displaced to either side with abdominal pads. A midline incision is made in the posterior parietal peritoneum from the region of L-1 to L-4, the incision paralleling the medial border of the aorta. Tilting the table sideways and elevating the kidney rest help the exposure. Both chains can be removed through this single posterior parietal peritoneum incision. On the right side, the vena cava must be rolled and displaced medially to uncover the sympathetic chain, which lies in the sulcus between the psoas muscle and the body of the veretebra. The chain is adherent to the vertebra and has a hard, cord-like feel, similar to the vas deferens. The chain is grasped with a clamp and held under tension as it is dissected from the surrounding tissues. The communicating rami of the chain point caudad on the third and fourth ganglia and cephalad at the first and second. The ganglion of L-1 is almost always covered by the diaphragm; therefore, it is removed by avulsion by grasping the uppermost exposed portion of the chain with a clamp and pulling caudad in the plane of the vertebrae. In this manner L-1 may frequently be removed. The chain often breaks up into many smaller segments below L-3, and it may be necessary to avulse the lower portion of the chain in a similar fashion. In an attempt to decrease the incidence of regeneration of the sympathetic fibers, silver clips are employed where the chain and communicating rami are divided. The lumbar veins which drain into the vena cava cross the chain and ganglia at right angles. It is usually possible to tease the chain gently from under these. If these veins should be torn and bleed, the hemorrhage is best controlled either by silver clips or by steady pressure with laparotomy pads for several minutes. On the aortic side, the chain is slightly more lateral; the dissection is a little more difficult here because of the aortic glands and their blood vessels.

Retroperitoneal Approach.—The patient is positioned so that he is partly on his side, the operative side being elevated about 45 degrees above the table horizontal plane. Sandbags under the elevated hip and shoulder maintain this position. The under leg is bent at the knee, and the leg on the operative side is kept straight, the two legs being separated by a pillow. This keeps the psoas on the operative side under tension so that it will not cover the chain and ganglia. The table may be broken at the lumbar level, tilted when necessary, and the lumbar rest elevated to improve the position further.

An oblique skin incision which begins at the tip of the 12th rib and extends obliquely downward and medially, reaching the lateral border of the rectus sheath at about the level of the umbilicus, is used. The external and internal oblique muscles are divided along the

course of their fibers, as is also the transversus abdominis muscle. The transversus muscle division must be carried out carefully, especially at the medial portion, to avoid opening into the peritoneal cavity. If the peritoneum is opened, it is promptly closed with a continuous Atraumatic absorbable surgical (gut) suture before the rent becomes extensive and the procedure is then continued. As the transversus abdominis muscle is divided carefully, the retroperitoneal space is immediately entered into. By means of gentle, pill-rolling blunt dissection with sponge sticks the peritoneum and its contents are pushed forward, a tissue plane being developed anterior to the kidney and psoas muscle. The peritoneum is mobilized from the anterior surface of the psoas muscle until the sulcus between the psoas muscle and the vertebrae is reached. On the right side the vena cava is gently retracted medially, and the sympathetic chain is identified by rolling it under the finger against the vertebrae. The chain is then removed as previously described for the transperitoneal approach. The procedure is slightly more difficult on the left side because of the aortic glands. After the chain is removed and hemostasis is secured, the muscles are permitted to fall together. The wound is then closed in layers. The resected sympathetic chain should always be submitted for pathological examination. Only in this way can one have incontrovertible proof that the specimen removed was truly the sympathetic chain.

RESULTS

The efficacy of lumbar sympathectomy in the treatment of occlusive vascular disease varies somewhat from clinic to clinic. Pratt [1] analyzed the results in a series of 504 sympathectomies performed during a five-and-one-half-year period from June, 1948, to December, 1953, inclusive. Three hundred nine of these operations were performed for occlusive arterial disease. Of the patients who had sympathectomies, 184 had arteriosclerosis without diabetes. There were 22 amputations in this group, a rate of 11%. Ninety-one patients had arteriosclerosis with diabetes; of these, 31 had amputations, a rate of 34%. This figure indicates the importance that infection, a much commoner problem in diabetics, plays in the patient's final outcome. There were 20 patients with thromboangiitis obliterans who underwent sympathectomy. Four of these required amputations, an amputation rate of 20%. Those patients who had sympathectomies for coldness and claudication of an advanced type had an amputation rate of 4.4%. When there was ulceration and infection, 32% required amputation. When there was actual gangrene, a 69% amputation rate was necessary. Of those patients who had pain at rest, 50% lost their limbs. Thus, gangrene, pain at rest, and ulceration were the most serious prognostic symptoms, in that order. In the total series of 309 sympathectomies for occlusive vascular disease, 80% did not require subsequent amputation in a six-month to five-year follow-up period.

Berry and co-workers [18] have recently reviewed the results of 397 lumbar sympathectomies performed on 275 patients during the period 1945-1952 for arteriosclerosis obliterans of the lower extremities. For purposes of evaluation the patients were divided into five clinical groups: (1) intermittent claudication only; (2) mild rest pain with or without intermittent claudication; (3) severe constant pain with or without intermittent claudication; (4) tissue necrosis with or without intermittent claudication and/or pain, and (5) asymptomatic, i. e., lumbar sympathectomies performed prophylactically in patients with one amputation to improve circulation in the contralateral limb.

Good results were those in which the patient felt that significant alleviation of symptoms had been obtained and he was reasonably satisfied. Such good results were obtained in 94 patients (34%), 16 of whom were dead at the time of the report. The highest percentage of good results occurred in those with intermittent claudication as the only symptom. Poor results without amputation were observed in 55 patients

(20%), 34 of whom were dead at the time of the report. One hundred nineteen amputations were performed in 107 patients, an amputation rate of 41%, bilateral amputation being necessary in 12. Fifty-one amputees had died. Of all patients operated on, 108 (39%) were dead. Comparison of patients with and without tissue necrosis revealed that there was a significantly higher percentage of good results if ulceration or gangrene had not developed. The amputation rate in patients with ulceration or gangrene was more than two and one-half times that of those without. Comparative analysis of diabetic and nondiabetic patients with ulceration or gangrene revealed the results to be essentially the same. As a result of the analysis of these cases, five categories of patients were classified as yielding minimal beneficial results from lumbar sympathectomy: (1) elderly diabetic persons (over 65 years of age) with clinical evidence of arteriosclerotic involvement of other organs or elevated systolic blood pressure, (2) severe atrophy of soft parts of the leg with evidence of marked capillary anoxia, (3) severe pain involving the foot or lower third of the leg with absent popliteal pulses, (4) a rapidly progressing process with widespread arterial involvement, and (5) gangrene or ulceration involving the foot in patients over 60 years of age with severe pain and obliteration of the popliteal pulses.

SUMMARY

The pertinent anatomy and physiology of the sympathetic system as applied to occlusive vascular disease of the lower extremities is reviewed. It is pointed out that because of residual pathways through the anterior roots of T-12 to L-3 it may be impossible to obtain complete sympathetic denervation of the lower extremities by use of the usual lumbar sympathectomy techniques.

The value of lumbar sympathectomy in thromboangiitis obliterans to overcome spasm in vessels adjacent to the site of active disease is pointed out. In diabetics with arteriosclerotic peripheral vascular disease, an important additional advantage of lumbar sympathectomy is the abolition of sweating in the denervated area. This prevents excessive moisture and prevents areas of maceration of the skin, especially between the toes, which may act as portals of entry for infectious organisms.

It is recommended that persons below the age of 55 with occlusive peripheral vascular disease should be subjected to lumbar sympathectomy. In older persons lumbar sympathectomy is reserved for those patients who show a good temperature elevation of the skin following posterior tibial or spinal anesthetic block.

In reviewing results in large series of cases, gangrene, pain at rest, and ulceration carried the worst prognosis, in the order mentioned.

The techniques of lumbar sympathectomy are reviewed. A retroperitoneal technique is recommended for its greater simplicity and ease of performance.

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Metabolic Derangements Imperiling the Perforated Ulcer Patient

V. Acceleration of Metabolic Rate and Altered Endocrine Activity

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INTRODUCTION

Weight loss is a charateristic sequel to ulcer perforation. Failure to meet the normal caloric demands by the parenteral route is undoubtedly in part responsible, but the possibility that elevation of the metabolic rate might also be a factor needs consideration. The depressing effect of malnutrition and debilitation on the metabolic rate has long been established,[1] and in the preceding papers we have shown that the patients of this series were undernourished.* The effect of trauma on the metabolic rate in such a debilitating condition, however, has not been demonstrated. In a study of previously healthy persons suffering cutaneous burns, a striking and prolonged elevation of the metabolic rate has been observed.[1] The rate returns to normal as the wounds heal. With a view to determining to what extent and for what length of time trauma and inflammation might change the caloric requirements of the patients with a perforated ulcer, studies were made of their metabolic rates. If the accelerating effect of trauma exceeds the depressing effect of malnutrition, the problem of maintaining the ulcer patient's nutritional status becomes more difficult.

Anticipating from the study of the burn patient that the metabolic rate might well be elevated, it was deemed wise to explore in addition the role of the adrenal cortex in the phenomenon. Increased adrenal cortical activity ordinarily depresses the rate of metabolism, but it also increases urinary loss of nitrogen. In healthy persons subjected to trauma, a pronounced loss of nitrogen occurs which is considered a part of the alarm response. Excessive nitrogen loss after ulcer perforation, however, has been shown in the preceding paper of this series to be slight and transient.[3] To determine whether the depleted and malnourished ulcer patient has an adrenal cortical output comparable to that of previously healthy traumatized subjects, a survey has been made of the pattern of the eosinophile count after perforation.

PLAN OF STUDY

Investigative Routine.—The main features of the investigative routine for the patients with perforated ulcers are described in the first paper of this series.[2] The rates of oxygen consumption of the patients were measured in the first waking hours in the morning. All patients were fasting in that they had taken no food by mouth since the preceding evening. A few, during the early postoperative period, had required an intravenous infusion during the

Submitted for publication April 20, 1955.

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This work was supported by a Contract between the Office of Naval Research and Harvard University.

* References 2 and 3.

night. The conditions under which these determinations were made cannot be considered basal, since the presence of a nasogastric tube and an operative wound inevitably disturb the patient's sleep, but an effort was made to minimize disturbing influences. The patients slept in single rooms, and the determinations were made there without moving the patients from their beds. The same technician made all determinations.

To provide figures for comparison of the effect of operation alone on the metabolic rate, as compared with operation and peritonitis, the rate of oxygen consumption was measured in six patients undergoing operative procedures of mild to moderate severity. These procedures included a vagotomy, two herniorrhaphies, two hysterectomies, and an adrenalectomy. The metabolic rate determinations were carried out under the same conditions as in the ulcer patients, with the exception that the measurements were made on the open ward and five of the six patients had no nasogastric tube.

Eosinphile counts in the patients with perforated ulcers were made on the day of admission and were repeated once or twice daily for the first two or three days and then every day or two. The bloods for the daily counts were drawn at the same hour each day.

Methods.—A portable Benedict-Roth respiration apparatus was used, and the metabolic rates were calculated from the Boothby and Sandiford modifications of the Dubois-Aub surface area formula.[5] Tests with an irregular respiratory line were discarded.

Eosinophiles were stained with the phloxine-propylene glycol solution recommended by Randolph[6] and counted in the manner described in a previous paper.[7]

In this laboratory the eosinophile counts of normal persons have been found to range from 70 to 250/cu. mm. A normal range of 120 to 240/cu. mm. is reported by Roche, Thorn, and Hills.[8] Rud,[9] who made hourly or quarter hourly counts on 42 normal subjects, reports average counts for individual subjects ranging from 48 to 334 eosinophiles per cubic millimeter.

METABOLIC RATE OBSERVATIONS

A. *The Patients with Perforated Peptic Ulcers.*—Fifty-three metabolic rate determinations were carried out in 12 patients with perforated ulcers. Exceptionally high rates were noted during the first three days. The decrease to normal thereafter was gradual (Chart 1 and Table).

Caloric Requirements at Rest Based on Average Morning Oxygen Consumption Rates of Twelve Patients*

Days After Perforation	Calories/24 Hr.
1	2,597
2	2,227
3	2,167
4	1,807
5	1,637
6	1,495
7	1,535
8	1,409
9	1,404

* Calculations from data of other investigators on the caloric requirements of normal healthy subjects at rest indicate an oxygen consumption by persons of approximately the same age and size as the patients in this series of 1530 calories per 24 hours (References 10 to 12).

Abrupt Initial Acceleration of Metabolic Rate:

The metabolic rate was elevated in 11 of the 12 patients during the first three days after perforation. No measurement was made until late in the week in the 12th case. The average measurement on the first postoperative day was +58, on the second +47, and on the third +34. Individual patients showed levels as high as 67, 78, and 112.

Prompt Return of the Metabolic Rate to Normal:

On the fourth and fifth postoperative days the average rates were +17 and +16, and

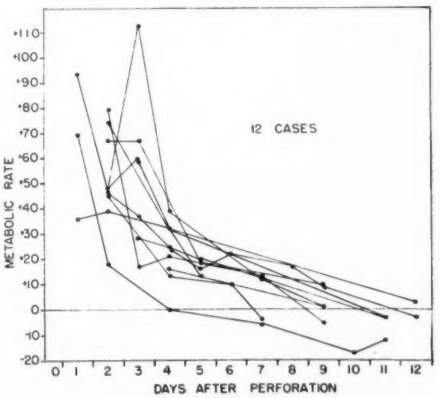

Chart 1.—Elevation of the metabolic rate following ulcer perforation and operation (12 cases). All patients studied showed an abnormally high oxygen consumption in the first three days. During the remainder of the first week the metabolic rates returned gradually to the normal range.

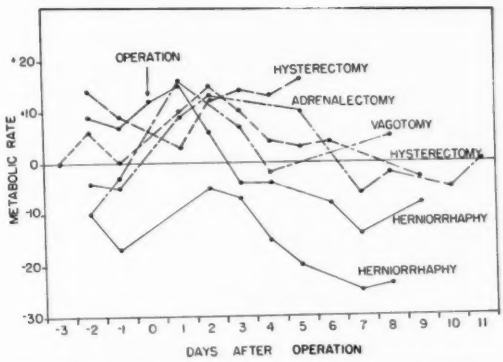

Chart 2.—Normal metabolic rates following operations unaccompanied by peritonitis (6 cases). The initial high oxygen consumption seen in the perforated ulcer cases was absent in the control group of patients who were subjected to operation unaccompanied by peritonitis.

by the end of the week they had fallen to the normal range (+9 and +5). Individual rates on the sixth and seventh days ranged from —6 to +17.

B. *The Controls.*—Fifty-one metabolic rate determinations were carried out in six patients who underwent operation but had no subsequent peritonitis (Chart 2). None of these measurements rose above +16. The majority were in the normal range, with one patient showing a subnormal oxygen consumption after the third day.

COMMENT

As anticipated from the similarity of the peritonitis following perforation to a cutaneous burn, caloric requirements are elevated in the patient with a perforated peptic ulcer (Chart 1). On the first two or three days after perforation, the metabolic rate rises to levels comparable with those seen in moderate or severe thyrotoxicosis. It is the peritonitis, rather than the operative procedure, which is responsible for this accelerated oxygen consumption. In contrast to the burn patients, the elevation in the ulcer cases is transient, lasting a few days instead of weeks, but, since the patients are generally undernourished before perforation, administration of high caloric nutriments cannot be slackened as the metabolic rate falls.

Three factors must be considered in seeking the origin of the accelerated metabolic rate: release of epinephrine from the adrenal medulla, hyperactivity of the thyroid gland, and increased local tissue metabolism. The specific dynamic action of protein can be ruled out, since the metabolic rate rose in patients on high, low, and protein-free intakes alike. Failure of six controls, patients undergoing major operations, such as vagotomy, hysterectomy, herniorraphy, and adrenalectomy, to show metabolic rates above the normal range suggests that epinephrine was not a factor (Chart 2), and, in addition, the elevation in the ulcer patient is too prolonged to be due to an outburst of epinephrine, unless the epinephrine is secreted throughout the first four or five days after perforation. The thyroid activity was not checked by measurement of the protein-bound iodine of the blood serum or by the radioactive iodine balance, but thyroid hyperactivity was considered unlikely in view of the negative results obtained in the burned patient.[4] The elevation was also too short to be of thyroid origin. If the initial rise to +50% were due to thyroglobulin it would last much longer, from many days to weeks. Increased tissue metabolism in the damaged peritoneum offers the most acceptable explanation of the increased oxygen consumption and caloric demands of the ulcer patient. Like the burn patient, a large wound area is involved.

EOSINOPHILE COUNT OBSERVATIONS

The number of circulating eosinophiles was counted repeatedly in 14 patients. An abrupt initial drop in count to a subnormal level was the rule. A subsequent rise was prompt in patients who did well and was delayed in those developing complications.

Initial Drop.—Eosinophile counts of zero or close to zero were found in 12 of the 14 patients whose counts were taken in the early hours (Chart 3). The counts of the two exceptional cases fell to similarly low levels after the patients were admitted (101 to 0 in one case and 38 to 2 in the other). The count generally remained low for 24 to 36 hours.

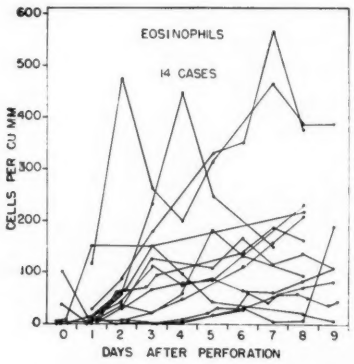

Chart 3.—Initial eosinopenia and subsequent reappearance of eosinophilic cells (14 cases). The counts of only three patients failed to rise above 20 by the third postoperative day. These three patients had stormy courses.

Customary Prompt Reappearance. — By the third postoperative day the counts of 11 patients had risen to above 100; those of only 3 patients remained below 20. The following day all but these three were above 45. Two cases showed transient rebound eosinophilia, reaching 450 and 566 on the fourth and fifth day, respectively.

Failure of Customary Reappearance in Patients Developing Complications.—The 3 patients whose counts remained low fared less well than the other 11. One, an asthmatic, required aspiration by bronchoscopy on the seventh postoperative day for partial atelectasis of his left lung. Fever, mounting daily to 103 F, subsided gradually after the aspiration. The patient's eosinophile count jumped from 8 to 188 two days after bronchoscopy. The second patient's eosinophile count remained at 2 or below through the fourth postoperative day. On the fifth day a wound dehiscence occurred. A gradual reappearance of the circulating eosinophiles took place after closure of the dehiscence. The counts of the third patient exhibiting

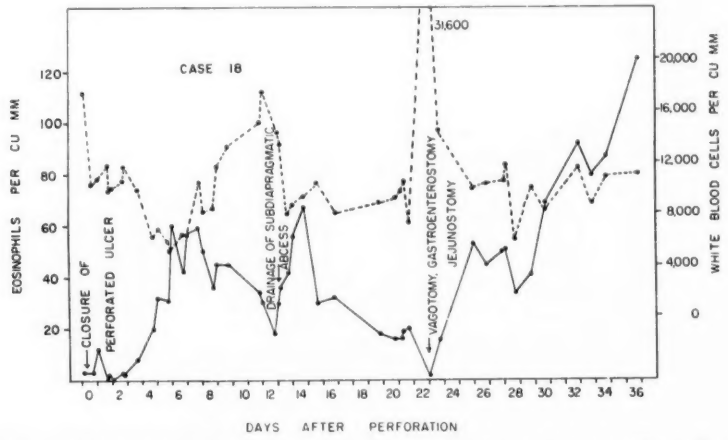

Chart 4.—Ominous significance of prolonged or recurrent eosinopenia (Case 18). The eosinophiles in this patient who developed first a subdiaphragmatic abscess and then pyloric obstruction were slow to rise after closure of his ulcer and took secondary drops just before clinical symptoms of the complications became apparent. The course of the white blood cells is also shown.

eosinopenia are shown in Chart 4. The customary rise in eosinophiles after operation was delayed and failed to exceed 60 cells per cubic millimeter. Two secondary falls occurred, one coincident with development of a subdiaphragmatic abscess and one just before clinical symptoms of pyloric obstructions became apparent. Not until the obstruction was relieved by an additional operative procedure did the eosinophile count finally return to normal.

COMMENT

Study of the course of the eosinophiles in these patients provides an excellent guide as to their prognosis, although failing to clarify the relationship of adrenal activity to protein metabolism in the previously debilitated patient. Failure of the eosinophiles to reappear by the third day after perforation is an ominous sign, and secondary drops may herald the development of complications. In the study of burns eosinopenia was found to have similarly grave prognostic significance.[7] Careful examination for complications should be made in all ulcer patients showing prolonged or secondary eosinopenia.

Unlike the excretion of nitrogen, the course of the eosinophile count in the patient with a perforated ulcer does not differ from that in previously healthy persons subjected to trauma. The adrenal cortex is apparently stimulated by the peritoneal insult, even though the nitrogen output is not affected.

Adrenal cortical activity ordinarily depresses rather than accelerates the rate of metabolism, as has been pointed out.[13] This is true in patients with spontaneous Cushing's disease and in patients with medical diseases, such as arthritis, treated with cortisone or corticotropin (ACTH). In the ulcer patients, however, the fall and subsequent rise of the eosinophile count is the mirror image of the rise and fall of the metabolic rate. This concomitance suggests that the two may be in some way related. Not until we understand more closely the influence of adrenal cortex outburst of the intermediary metabolism of proteins and upon the eosinophiles will we know whether there is a substance to this relation.

SUMMARY AND CONCLUSIONS

Serial measurements of the metabolic rate have been made in 12 patients with perforated peptic ulcers treated by operation. Similar measurements have been carried out in six patients undergoing operations for other conditions unaccompanied by peritonitis.

The metabolic rate of the patient with a perforated ulcer treated by simple surgical closure is abnormally high for the first three days. The rise is transient, subsiding gradually to normal at the end of the first postoperative week.

No similar elevation of the metabolic rate is observed in patients undergoing operations in the absence of peritonitis.

Etiologic factors in the metabolic rate elevation are discussed.

Serial measurements of the eosinophile count have been made in 14 patients with perforated ulcer.

An abrupt initial fall in eosinophile to subnormal levels followed by a prompt rise is characteristic of those whose convalescence is uneventful.

Prolonged or recurrent eosinopenia following ulcer perforation is a grave prognostic sign.

The relation of adrenal cortical activity to metabolic rate is discussed.

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Carcinoma of the Scrotum

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Carcinoma of the scrotum has been sparsely discussed in American texts and journals. This is principally a reflection of the waning incidence of the disease in this country. Nevertheless, it continues to present a formidable problem in treatment of the primary lesion and in management of advanced disease. The accompanying case report well illustrates the inevitable course which this disease may be expected to pursue in a large proportion of the cases. It further emphasizes this unique type of squamous-cell cancer of the skin.

INCIDENCE

In his classical monograph on carcinoma of the scrotum, Henry [1] states that this entity accounts for just less than 8% of all deaths from cancer of the skin reported annually in England. It also accounts for 0.25% of all deaths from all cancers. Up to 1943, Henry had quoted 1355 cases of carcinoma of the scrotum in Great Britain. In statistical studies done in this country, Hueper [2] cites the figures from the United States Registration Area (Hoffman) from 1926 to 1929 and states that during this period there were 133 deaths from carcinoma of the scrotum and 710 deaths from cancer of the penis. At the Brady Urological Clinic, in Baltimore, only 2 cases of carcinoma of the scrotum were found among 12,000 consecutive admissions. In the past nine years, only two cases of carcinoma of the scrotum have been seen in the Veterans Administration Hospital, Bronx, N. Y., a 1500-bed general hospital.

Submitted for publication June 8, 1955.

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ETIOLOGY

Numerous industrial carcinogens have been implicated as etiological agents in cancer of the scrotum. Percival Pott [3] suggested many carcinogenic substances as causative factors, in his early monograph of 1775. These included tars, pitch, paraffin, mineral oil, coal tar, arsenic, shale oil, bitumen, and others. This type of epithelioma was said to be prevalent in chimney sweeps, who were constantly exposed to tar derivatives in soot during a long period of time. The latency of this variety of occupational cancer has also been emphasized. Haagensen [4] cites several examples of proved scrotal carcinoma occurring in patients as long as 19 years subsequent to occupation as chimney sweeps and as long as 14 years after cotton "mule spinning." Southam [5] recorded coexisting primary cancer of the lung, tonsil, and stomach. He believed that these organs, as well as the scrotum, were exposed to carcinogens. Kennaway [6] indicated that the prevention of exposure to the various carcinogens as well as cleanliness of the genitalia were factors necessary for decreasing the incidence.

It was suggested by Leitch [7] that the sebaceous secretion of the glands in the skin of the scrotum acts as the solvent of the soot in humans and is a necessary step in the production of the lesion. Southam [5] also recognized the occupational relationship and

cited the predominant site for cancer of the scrotum on the left side. This he attributed to the position of the cotton "mule spinners" during their work.

TREATMENT

The treatment of carcinoma of the scrotum and inguinal metastases is surgery. The use of electrocautery, silver nitrate, and other superficial caustic agents prior to histological verification is to be decried. In view of the extensive lymphatic anastomosis and the high incidence of bilateral inguinal metastases, it is logical to base therapy on radical excision of the primary lesion and a bilateral block dissection of the inguinal nodes. The role of radiotherapy is one of palliation only, as is well demonstrated in the case presented. Before undertaking therapy, one must make every effort to delineate the extension of the metastatic process. Ureterograms, cystograms, and barium contrast enemas may be helpful in this connection.

PROGNOSIS

The poor survival rate in this disease is supported by observers in many clinics. Graves and Flo [8] reported on 12 cases seen over a 12-year period in their clinic. Only one patient remained alive, despite wide block dissection of lymph nodes. The average survival time was nine months in his group. In Dean's [9] series of 27 patients at the Memorial Hospital, the over-all survival rate was only 22.2% of his cases. It further emphasizes the truly unfavorable prognosis. Of 16 patients in Dean's group with inguinal metastases on initial examination, only 2 survived five years. Henry [10] mentions a 14% survival rate in 155 patients seen at various clinics in England.

The striking disparity between the prognosis for cure in squamous-cell carcinoma of the skin generally (70-80% *) and squamous-cell carcinoma of the scrotum in particular (15-20%) is not generally appreciated. Several factors may account for this vast difference in the prognosis between these two apparently identical histological entities. These include (1) late arrival of the patient for treatment, (2) failure of the physician to recognize the remarkably aggressive nature of the lesion, and (3) the vast lymphatic anastomosis between the two sides of the scrotal sac, allowing prompt metastasis to both groins. Rouvière [13] has called attention to this important anatomical factor, which should reflect the decisions and treatment policy (Fig. 1). Morley,[14] in discussing his cadaver dissections, states that "in consequence of the free anastomosis of the superficial lymphatic network of opposite sides, it is obvious that whenever an epithelioma approaches the median raphe, the glands of both groins. Rouvière [13] has called attention drainage of the scrotal sac leads inevitably to the deep and superficial inguinal lymph nodes.

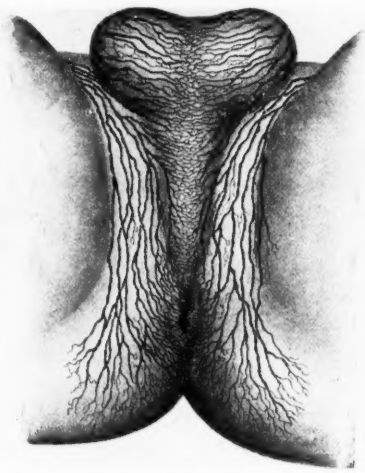


Fig. 1.—Lymphatic drainage of the scrotal sac. (Reproduced by permission of Masson & Cie, Paris, France, from H. Rouvière: Anatomies des lymphatiques de l'homme, 1932, Fig. 108, p. 384.)

REPORT OF A CASE

The patient, a 56-year-old white man, entered the hospital on Oct. 3, 1952, with complaints of a slowly growing, nontender mass located on the left side of the scrotal sac. This had been present for a

* References 11 and 12.

period of 10 to 20 years and treated conservatively with antibiotics, electrocautery, and silver nitrate, without success in its control. There was a history of exposure to tar products 10 years prior to admission over a 3-year period. This occupation consisted of marking steel with tar derivatives.

The physical findings included a large (5 cm.) ulcerated, necrotic lesion in the left scrotal area, with a serosanguinous discharge and palpable lymph nodes in the left groin. X-rays of the chest were normal. An intravenous pyelogram revealed displacement of the lower portion of the left ureter and indentation of the left upper margin of the bladder. Serology was negative. Biopsy of the scrotal mass disclosed epidermoid carcinoma, Grade 2 (Fig. 2).

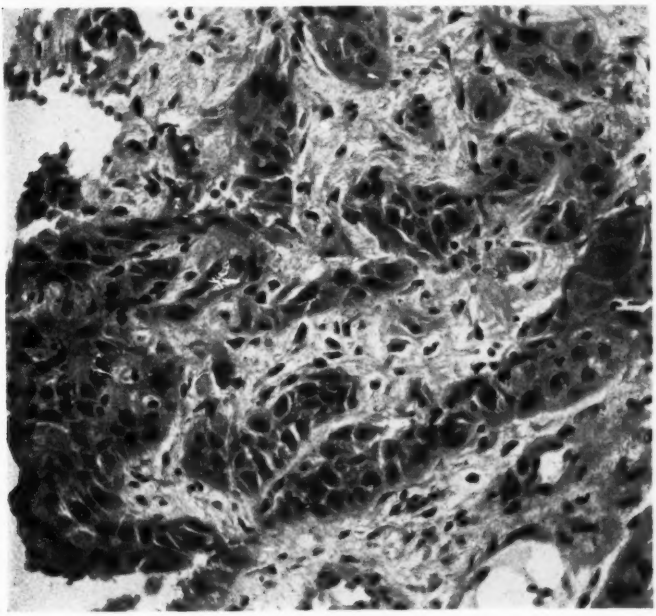


Fig. 2.—Photomicrograph of original lesion of scrotum. Epidermoid carcinoma, Grade 2.

On Oct. 10, 1952, a left orchiectomy and excision of the left scrotal carcinoma was done. This was followed by a dissection of the left inguinal and left iliac nodes. The histological findings showed metastatic disease in one of seven excised lymph nodes. The patient subsequently had a split-thickness graft to a granulating wound of the left groin. He was discharged on Nov. 26, 1952.

His second admission was nine months later, on July 15, 1953, because of a palpable mass in the right groin of two months' duration. At this time, physical examination revealed two hard, irregular inguinal nodes on the right, each 4 cm. in diameter. The left side showed a healed groin scar with no gross evidence of recurrence. The left leg, scrotum, and penis were edematous. A needle biopsy of the right groin showed epidermoid carcinoma.

On July 28, 1953, a right radical ileoinguinal lymph-node dissection was performed. Metastatic disease was found in lymph nodes at that time. The patient was discharged on Sept. 24, 1953.

His third, and last, admission was on Nov. 3, 1953, because of swelling in the region of the right groin. Physical examination disclosed bilateral inguinal scars, with a large, ulcerated, fluctuant mass (Fig 3*A*) on the right. There was concomitant swelling of the right groin, right leg, and remaining scrotal area. The left leg at this time was not edematous.

On Nov. 9, 1953, an attempt was made to excise the mass in the right groin but was unsuccessful because of the infiltrative nature of the mass. An attempt was also made to do a split-thickness graft at this time.

On Dec. 8, 1953, radiotherapy to the right inguinal area was begun, utilizing 1000 kv., 3.9 mm. lead half-value layer, 70 cm. target-skin distance, through a field measuring 17×17 cm. A tissue dose of 3000 r was delivered in a 28-day period. The original mass as the beginning of therapy measured 10×15 cm. and was gradually reduced to 4×6 cm. within one month after the completion of therapy

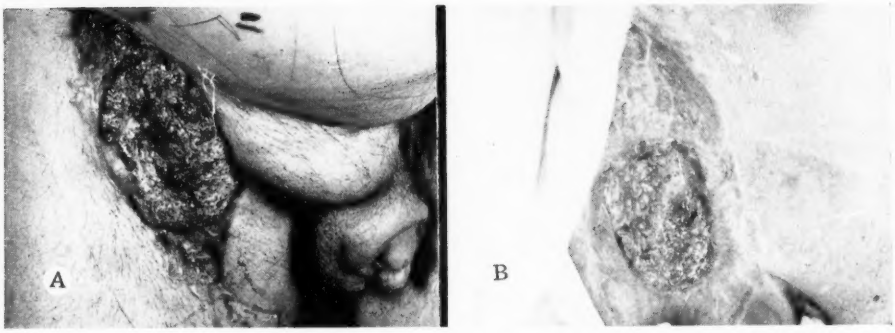


Fig. 3.—*A*, Appearance of ulcerated area of right groin prior to x-ray therapy. *B*, Right groin area, postirradiation, showing reduction in size and improvement in appearance of lesion.

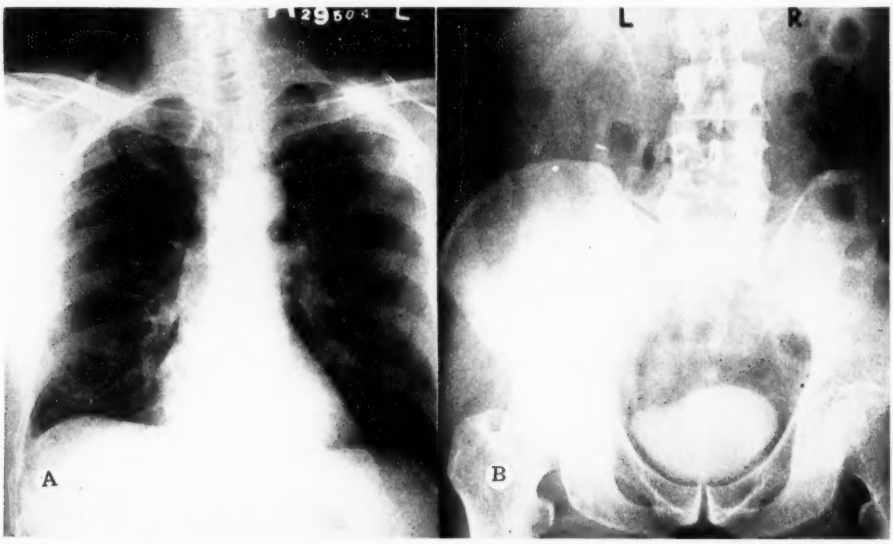
(Fig. 3*B*). X-rays of the chest on Dec. 10, 1953, revealed numerous metastatic nodules (Fig. 4*A*). An intravenous pyelogram on Feb. 10, 1954, showed bladder indenture by tumor mass (Fig. 4*B*). Despite the response to radiotherapy, the patient's complaints of pain in the sacral and lumbar area became progressively severer. On Jan. 21, 1954, chordotomy at the level of T-2 to T-3 was performed on the right, with a rhizotomy at T-2 on the left and T-3 on the right. The patient's pain persisted, and he failed progressively, dying on March 21, 1954.

The postmortem findings included metastatic squamous-cell carcinoma to the lungs, lymph nodes, anterior mediastinum, mesenteric nodes, right psoas, muscle, right sciatic nerve, sacral vertebrae, skin, subcutaneous muscle, bilateral inguinal areas, and the tissues of the right thigh.

COMMENT

In reviewing the patient's occupation, it became obvious that the hands were frequently in contact with a known carcinogenic substance, namely, tar. It is not unlikely that, as a result of contact with soiled trousers or tar-soiled hands, the scrotum was subjected to frequent irritation with the tar

Fig. 4.—*A*, X-rays of mass in the chest on Dec. 4, 1953, showing metastatic nodules throughout both lungs. *B*, Intravenous pyelogram of Feb. 10, 1954, demonstrating indenture on the left superior aspect of the bladder by a mass.



substance during a three-year period. The 10-year period of latency, before the appearance of the malignant disease, is in keeping with the well-established clinical observation. The most significant factor in the discussion of this disease is its striking superficial resemblance to relatively less malignant squamous-cell cancer of the skin, despite its extraordinarily malignant biological behavior.

SUMMARY

In this country carcinoma of the scrotum is a rare and unusual disease, characterized principally by its extremely malignant behavior, in spite of its superficial resemblance to other squamous-cell cancers of the skin. A case report has been included.

The poor survival rate, in spite of aggressive surgical therapy, has been emphasized, and the factors probably responsible have been outlined.

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The Roentgenogram in Perforated Peptic Ulcer

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Surgeons have realized the value of the roentgenographic examinations as an aid in the diagnosis of perforated peptic ulcer for some time. We have been able to demonstrate that a multiple position technique significantly increases the diagnostic accuracy, as compared with a single film taken in the upright position, which is frequently all that is made.

Popper [1] advocated the upright position as early as 1915 to demonstrate free air in the abdominal cavity. According to Cole and Berne [2] the accepted diagnostic accuracy of the x-ray examination in perforated peptic ulcer is between 75% and 80%. Kornblum [3] reported the incidence of pneumoperitoneum in 87 cases of perforations of the gastrointestinal tract. The free air was demonstrated in 59.3% of the stomach perforations and 70.4% of the duodenal perforations. Vaughn and Brams [4] utilized either the upright or the lateral decubitus position and obtained an accuracy of more than 82% in their 29 reported cases of perforated peptic ulcer, in 1925. Vaughn and Singer [5] published a report in 1929 of 63 cases with a diagnostic accuracy of 87%. Nichols [6] in 1950 reported a diagnostic accuracy of about 79% in his 29 cases of perforated hollow viscus. Williams and Hartzell [7] reported 76% positive results in a series of 227 cases in which the upright film was utilized, but in a series of 68 patients in which the x-ray was taken in the left lateral decubitus position in addition pneumoperitoneum was demonstrated in about 90% of these cases. Frimann-Dahl [8] advocated films made in the supine lateral position in addition to the upright and lateral decubitus views.

Submitted for publication Aug. 29, 1955.

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MATERIAL

We have studied 157 cases of perforated peptic ulcer, all those at Hines Veterans Administration Hospital during the past nine years in which the diagnosis was confirmed at surgery (152 cases) or autopsy (5 cases). Our cases have been tabulated according to the number of x-ray positions used—one, two, three, or four. Specifically the positions were upright, right lateral decubitus, left lateral decubitus, and supine lateral.

Age Incidence.—Our cases varied in age from 21 to 84 years, the average being 36.2 years, 35 cases being in the 20-30 year age group, 38 in the 30-40 year age group, 34 in the 40-50 year age group, 35 in the 50-60 year age group, and 15 in the group 60 years and more. This indicates that perforated peptic ulcer does not restrict itself to any particular age decade.

To obtain statistical uniformity, we did not include three cases with two or more examinations. In these, the first examination was negative, but on subsequent x-ray examination free air was demonstrated.

TECHNIQUE

In the early years of this study, a single posteroanterior film including the diaphragm was taken in the upright position. Later, a three-position examination was made—from the upright and the right and left lateral decubitus positions. The right lateral decubitus position is that in which the patient lies on his right side and a posteroanterior film is made with the radiographic tube brought down be-

Fig. 1.—The right lateral decubitus position. The patient lies on his right side and a postero-anterior film is made with the radiographic tube brought down behind him and the film in front. The free intraperitoneal air is visible beneath the left lateral abdominal wall under the diaphragm. The stomach has a fluid level and is carried down by the weight of its content.

hind him and the film in front (Fig. 1). The direction of the x-ray beam at this time is horizontal. Free intraperitoneal air rises as high as possible, so as to lie under the left lateral abdominal wall, where it may have to be differentiated from air in the stomach and colon. The left lateral decubitus position (Fig. 2) has the advantage that free air (if present) will be shown between the right border of the liver and the lateral abdominal wall and is not confused with the gas-containing viscera. A still later addition was the supine lateral position, which with the three positions described above constitutes the four-position routine. In this latter view (Fig. 3) the patient lies on his back; the radiographic tube is brought down to either flank, and the film is supported on the opposite side, the x-ray beam being horizontal. If free air is present, it can be demonstrated under the anterior abdominal wall. In none of these views is the Bucky diaphragm used.

Fig. 2.—The left lateral decubitus position showing free air beneath the right leaf of the diaphragm.

RESULTS

In the entire group of 157 cases the x-ray examination was positive in 133 instances (84.7%). When the single upright position was used (17 cases) 13, or 76.5%, were positive. With the three-position technique (68 cases) the accuracy was 85.3%, or 58 positive cases. The four-position technique (66 cases) demonstrated free air in 56 cases, or 84.9%. There were only six cases with the two-position technique. The x-ray was positive in all of these instances. These results are expressed in the Table.

Reliability of Roentgen Examination in Perforated Peptic Ulcer

Positions, No.	Cases, No.	Positive Cases, No.	Negative Cases, No.	Per Cent Positive
1	17	13	4	76.5
2	6	6	0	100.0
3	68	58	10	85.3
4	66	56	10	84.9
All	157	133	24	84.7

There is a significant increase in diagnostic accuracy when multiple positions are used. In two instances only the supine lateral position film was positive, whereas the films in three other positions were negative.

The majority of our perforations were anterior duodenal (131 cases, or 83.4%); 24 were gastric, of which 20 were prepyloric. In the gastric group only one greater curvature perforation was found. There were two perforated ulcers distal to the duodenum.

COMMENT

Failure to demonstrate free air in the peritoneal cavity on the roentgenogram does not mean that a perforated peptic ulcer is not present; we were not able to demonstate free air in 15.3% of our 157 cases. We do not know the reasons for this, although Thaxter [9] states that the amount of gas present is dependent on the time which has elapsed since perforation, the effectiveness of the reaction in walling off the perforation, the amount of air in the stomach at the time of perforation and the amount swallowed since, the amount of fluid in the stomach, and the positions assumed by the patient since the perforation.

Most of the patients in this series had an elevated serum amylase. This may be due to irritation of the pancreas. The vast majority of our patients had anterior duodenal perforations. Operative manipulation was not a factor in that these determinations were made

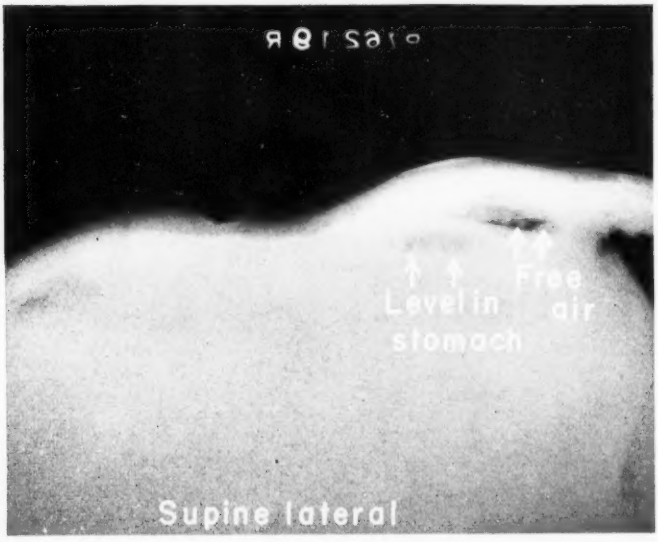


Fig. 3.—Supine lateral position. The patient lies on his back. The direction of the x-ray beam is horizontal. Free air is beneath the anterior abdominal wall below the diaphragm.

Fig. 4.—Air is in the hepatorenal space in this anteroposterior film of the abdomen. All routine positions showed free intraperitoneal air.

preoperatively. In one case, not included in this series, the first x-ray examination was negative. The patient was treated for pancreatitis because of the high serum amylase. Subsequent x-ray examinations were positive for free air. Therefore, the diagnosis of perforated peptic ulcer may be most difficult at times, with a high serum amylase and negative x-ray examination.

A "free-air series" is understood at this hospital to mean x-ray films taken in the upright, right and left lateral decubitus, and supine lateral positions, all showing the diaphragm. In the past surgeons often requested a "flat plate of the abdomen." As a rule, the x-ray technician then made an ordinary anterior-posterior Bucky film, which was not likely to be helpful. The meaninglessness of the term "flat plate" can be seen when it is recalled that films have been used instead of plates in roentgenography for more than 25 years, and films are made in no other shape than flat.

Unusual Localizations of Air in the Abdomen.—On a number of occasions recumbent posteroanterior and anteroposterior films of the abdomen showed air localized in an unusual manner. Air was demonstrated in the hepatorenal space in six instances (Fig. 4). In five of these cases air was detected on the films made in the recumbent anteroposterior and posteroanterior positions and in the sixth on the film taken in the right lateral decubitis position. In another case, in addition to free air under the left diaphragm, fixed air was present high on the left side, going into the left psoas sheath (Fig. 5). This fixed air did not change, regardless of the position of the patient. In other cases with anterior duodenal perforations free intraperitoneal air was demonstrated, and there was also some retroperitoneal air extending along the left psoas sheath. One patient showed extension of air from one psoas sheath into the mediastinum. There were three patients who showed fixed air in the psoas sheath in ordinary anteroposterior films (Figs. 5 and 6) as well as free intraperitoneal air. The mechanism of this localization is not understood. In no case in this series was free air demonstrated in the lesser peritoneal sac, either radiographically or on surgical exploration.

Other Radiographic Findings of Interest.—There was evidence of free fluid in the abdomen in 27 cases. In these instances a fluid level was seen in appropriate positions, because of the presence of free air plus fluid.

Fig. 5.—Anteroposterior recumbent film showing fixed intraperitoneal air in the left psoas sheath. A small amount of free air was seen in the right lateral decubitus position.

There were 54 patients who showed evidence of ileus. Among this group 18 showed distention of the small intestine but not of the large bowel. Fluid levels were seen in the small intestine in 20 cases. These data are of interest in connection with the radiological differentiation between organic obstruction of the small bowel and paralytic ileus. They showed that distended loops of small bowel with fluid levels do not necessarily mean small-bowel obstruction, for none of these patients had obstruction. The paralytic ileus can be readily explained by the peritonitis. It is our impression that in addition there is associated pancreatitis, which can also produce ileus.

On several occasions examination made in the anteroposterior position showed a sign, which has been described by Rigler,[10] visibility of the outer wall as well as the inner wall of the bowel due to the presence of intraperitoneal air (Fig. 7). In all these cases the free air was readily diagnosed in films made in other positions described above.

We believe that multiple films in various positions are valuable because there is an

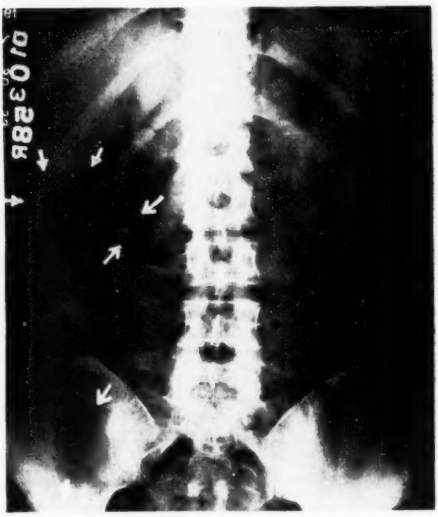
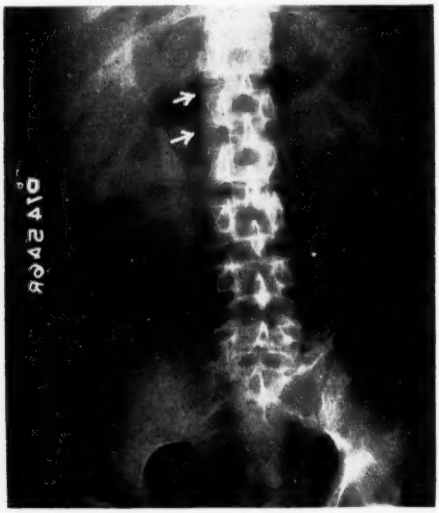


Fig. 7.—The outer as well as the inner border of the bowel is visible (Rigler's sign) in this anteroposterior recumbent film of the abdomen. Routine views showed much free intraperitoneal air.

8.8% increase in diagnostic accuracy when compared with a single film taken in the upright position. The supine-lateral position did not increase the diagnostic accuracy percentagewise; however, in two instances, this was the only position from which the diagnosis of pneumoperitoneum could be made. For this reason, we believe it is worth while continuing the four-position procedure.

Fig. 6.—Air is visible in the right psoas sheath. This anteroposterior Bucky film was made with the patient on his back. Free air was seen in all four routine positions, in addition, air being in the hepatorenal space.



CONCLUSIONS

It is possible to demonstrate free air in the peritoneal cavity with the roentgenogram in 76.5% of cases of perforated peptic ulcer when the upright position is utilized.

The diagnostic accuracy of pneumoperitoneum can be increased to about 85% with use of at least three roentgenograms. The additional views found to be of value are made in the right and left lateral decubitus and supine lateral positions.

Radiographic findings occasionally encountered in the routine anteroposterior recumbent position which may be of diagnostic value are visibility of the outer wall of the bowel, air in the psoas sheath, and air in the hepatorenal space.

Most perforated peptic ulcers are anterior duodenal.

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The Formation of a Functional Artificial Bladder in the Human Male

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The first reported study on the problem of creating an artificial bladder was that of Tizzoni and Foggi,[1] in 1888. They isolated a 7 in. segment of ileum and anastomosed the ureterovesical tissue into its proximal end. Then, at a second stage they anastomosed the distal end of the segment to the neck of the bladder. Two months later the dog appeared normal, except for frequency of urination.

The next experimental work was by Bisgard,* in 1943. He used segments of terminal colon to construct an artificial bladder in two stages. The immediate results were good, and dogs living two years still showed an essentially normal urinary tract. Rubin,[4] in 1948, and Thompson,[5] in 1949, repeated Bisgard's work with successful results. Davids and Bellwin,[6] in 1954, repeated the work of Tizzoni and Foggi, using 35 cm. segments of ileum. Their dogs showed poor nutrition and suffered from acidosis until they shortened the loops to 20 cm., thus illustrating the relation of the size of bowel segments to the problem of electrolyte imbalance.

The first clinical attempt to solve this problem was by Pawlik, who performed the first total cystectomy and utilized the vagina to create an artificial bladder in 1889. Except for poor control and a persistent urinary fistula, the operation was a success and the patient survived 16 years.

Lemoine,[8] in 1913, used the rectum in one case, and Goldstein, Rubin, Sachs, and Weisberg,[9] in 1953, used the sigmoid in two cases, to form an artificial bladder in the human. These cases survived 18 days, 5 months, and 8 months respectively. Failure of the anastomosis, with subsequent complications, was responsible for death in all cases.

We wish to present the case of a 32-year-old white man who complained of painless hematuria for 10 years and who has had multiple and recurrent bladder tumors fulgurated four times in the last 2 years. Clinically, this tumor was classified as Grade 2 carcinoma. Microscopically, the lesions were confined to the mucous membrane. Physical examination was entirely negative. Barium enema examination showed a normal colon. The sigmoid was of adequate length. The bowel was prepared during a period of one week with catharsis, sulfonamides, and antibiotics.

At operation with the patient under continuous spinal anesthesia, a segment of the lower bowel consisting of the distal half of the sigmoid and the proximal half of the rectum was isolated with its blood and nerve supply intact. The proximal end of the bowel segment was closed by suturing and the segment irrigated with isotonic saline; 2 gm. of

Recorded for publication Aug. 29, 1955.

Read at the 12th Annual Meeting of the Central Surgical Association, Chicago, Feb. 19, 1955.

The research work leading to this operation was carried on over a period of five years at the Wayne University College of Medicine, Department of Surgery, through a grant from the Detroit Receiving Hospital Research Corporation.

Clinical Assistant Professor of Surgery, Wayne University, and Attending Surgeon, Chief, Section of Rectal and Colonic Surgery, The Grace Hospital (Dr. McLean); Consulting Surgeon, formerly Chief, Section of Urology, Division of Surgery, The Grace Hospital (Dr. Hull); Assistant, Division of Surgery, Section of Rectal and Colonic Surgery, The Grace Hospital (Dr. Arminski).

* References 2 and 3.

Fig. 1.—Isolated segment of bowel used to form the artificial bladder. The segment consists of the lower half of the sigmoid and the upper half of the rectum.

neomycin in 100 cc. of water for injection U. S. P. was placed in the segment and the distal end closed with a single blade of a Wolfson Clamp. The midsigmoid and mid-rectum were then anastomosed end to end with two layers of interrupted suture.

A total cystectomy was then performed preserving the seminal vesicles and prostate, which were normal.

The bowel segment was then anchored in its upper posterior aspect to the fascia over the fifth lumbar vertebra below the bifurcation of the great vessels. The ureters were anastomosed to the posterior surface of the bowel segment by a two-layer interrupted-

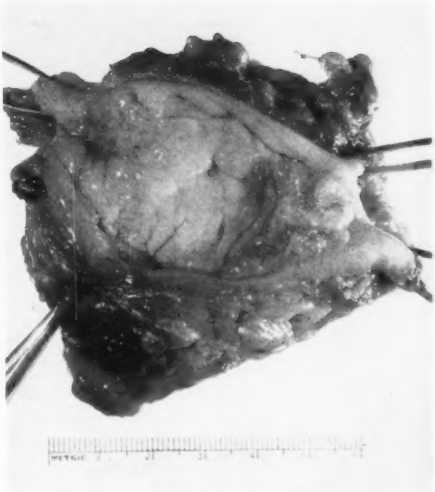

Fig. 3.—The excised urinary bladder showing a recurrence of the neoplasms six weeks after fulguration.

suture elliptical anastomosis over a No. 10 urethral catheter which was anchored in place by a 00000 chrome absorbable surgical (gut) suture at the site of anastomosis. The catheters were brought out through the distal end of the bowel segment for external drainage.

The rectosigmoid area of the bowel segment was then sutured to the top of the

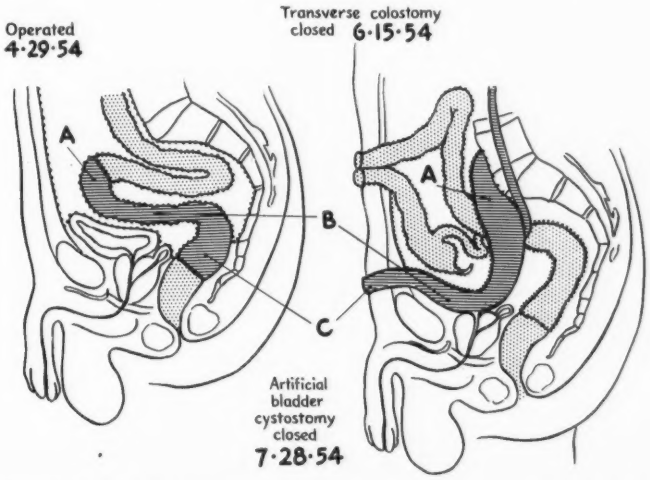

Fig. 2.—Left, diagram showing the location of bowel segment used to form the new bladder. Right, the method of utilizing the segment to form the bladder.

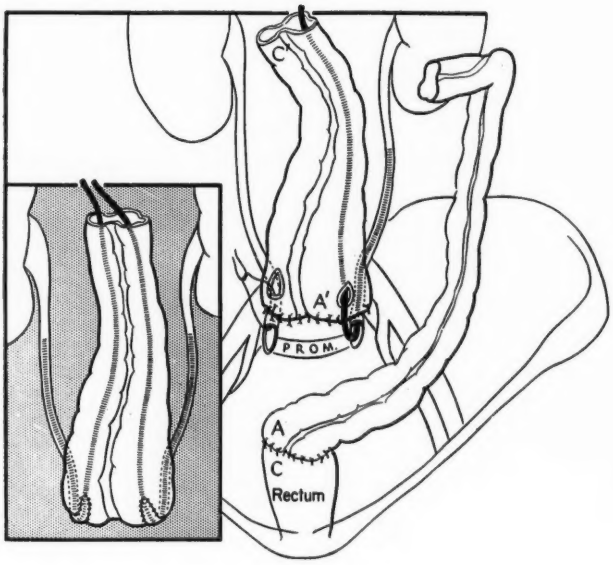

Fig. 4.—Diagram illustrating technique of direct eliptical ureterointestinal anastomosis over a No. 10 urethral catheter.

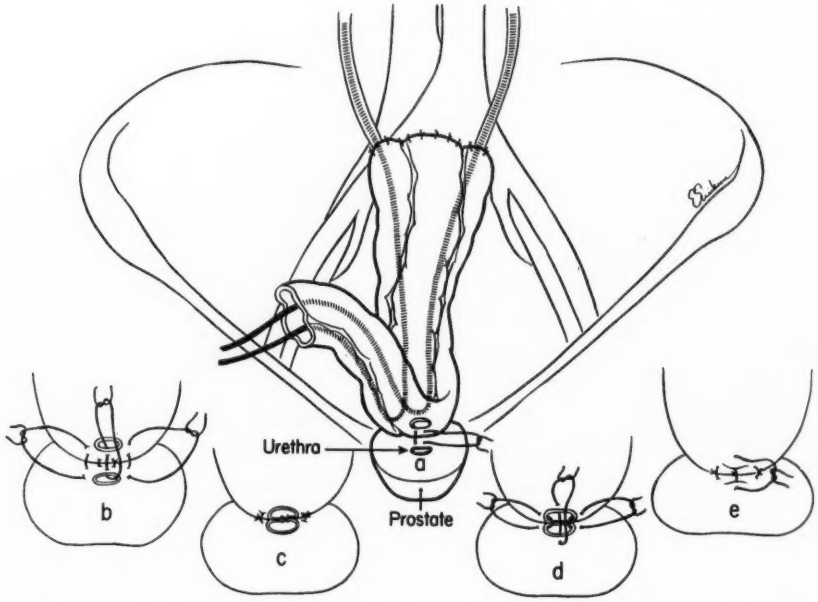

Fig. 5.—Diagram illustrating the technique of end-to-side anastomosis of the prostatic urethra of the bowel-bladder.

prostate, and a 0.5 cm. opening was cut in the bowel wall and anastomosed in two layers with the prostatic urethra, thus making an end-to-side anastomosis between the prostatic urethra and the artificial bladder. A Foley catheter with a 30 cc. bag was introduced through the urethra into the bowel segment before the last two anterior sutures were tied. Retroperitoneal Penrose drains were carried down to the site of each of the anastomoses. The distal end of the bowel segment was brought out through the wound above the pubis.

The peritoneum was then sutured to the sides of the new bladder and closed above the distal portion that was exteriorized. A temporary transverse colostomy was then made to protect the suture lines from possible contamination.

After operation, the patient progressed normally except for one complication, which appears to be physiological, following this procedure. The urethral catheters drained well, but there was very little drainage from the catheters in the urethra and cystostomy opening.

By the third postoperative day, it became apparent that the new bladder was forming a great deal of very thick, heavy, tenacious mucus. This mucus blocked the catheters draining the bladder, and on the fifth postoperative day a urinary fistula formed at the site of the urethral anastomosis. All attempts to wash the mucus from the bladder were unsuccesssful. Finally, on the 18th postoperative day, a sigmoidoscope was passed through the cystostomy opening, and the mucus was removed with a forceps. About this time the patient began voiding through the urethra around the catheter. On the 34th postoperative day, the fistula closed. The next day the patient was started on deep x-ray therapy over the artificial bladder in an attempt to inhibit the mucus. The patient was given 1928 roentgen units in 16 doses over a period of 22 days. During the treatment the mucus decreased in amount, and became thinner so that it could easily pass through the urethra. On the 47th postoperative day the transverse colostomy was closed.

On the 50th postoperative day the Foley catheter was removed. From that time on

Fig. 6.—Barium enema showing (*A*) normal colon with adequate sigmoid loop; and (*B*) colon after segment was removed and anastomosis healed.

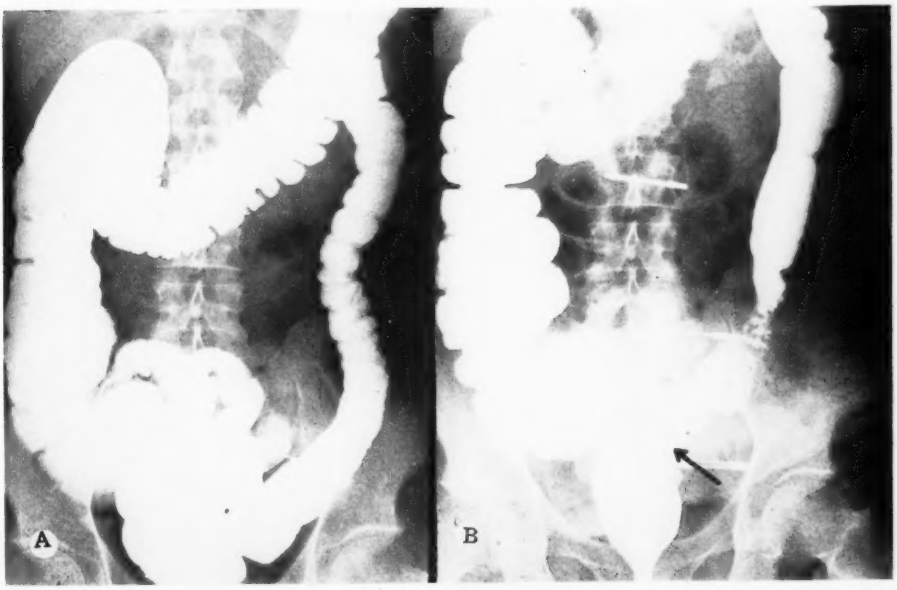

Fig. 7.—Cystogram showing 325 ml. of 10% sodium iodide in bladder. Note tendency of the sigmoid to resume its former position.

the patient voided well through the urethra with perfect control. Cystograms made at this time showed no reflux with a filling to 325 ml. of 10% sodium iodide. The bladder was able to hold more than 450 cc. of urine. A voiding cystogram shows the loss of the internal sphincter and the control by the external sphincter.

X-rays made after the patient has voided the sodium iodide solution show that evacuation of this solution is not complete. The patient asserts that he has difficulty in voiding the iodide solution but that he can empty the bladder of urine.

We believe that he does carry some residual, but the amount is difficult to determine. On several occasions we have been able to recover from 2 to 10 cc. of urine after the patient has voided, but on withdrawing the catheter we have noted that it is usually plugged with mucus. It is our belief that there is considerable variation in the completeness of the emptying of this bladder. Further studies on function will be reported later.

The prostatic urethra is now a part of the bladder cavity. The desire to void is felt first in the glans penis and then in the whole organ. Both voluntary and involuntary control are perfect.

Intravenous pyelograms are essentially normal.

Fig. 8.—Cystograms showing (*A*) voluntary voiding and (*B*) voluntary control of bladder contents by external sphincter.

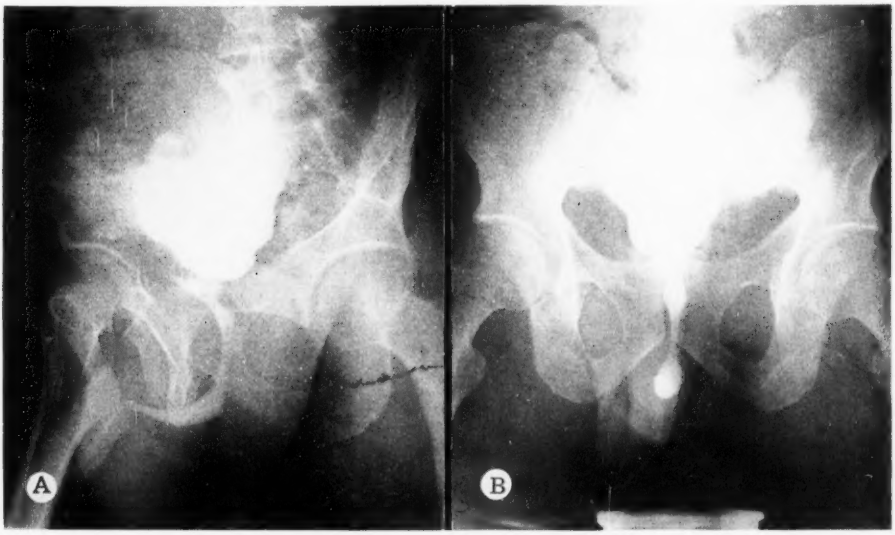

Fig. 9.—Intravenous pyelograms showing essentially kidney pelvis.

On a second admission, on July 28, 1954, the cystostomy opening was closed.

SUMMARY

We are reporting a case in which we have succeeded in constructing a functional urinary bladder from a 35 cm. segment of lower sigmoid and rectum attached to the prostatic urethra.

The essential parts of the operation were carried out in one stage, leaving only the closure of a colostomy and cystostomy for a later date.

A troublesome complication in the postoperative course was the plugging of the catheters with mucus. The problem of mucus secretion was satisfactorily handled by x-ray therapy over the new bladder. A urethrovesical fistula developed when the catheter became plugged and healed when adequate drainage was established.

Since removal of the urethral catheter, the patient has been able to void at will and has had no trouble with incontinence at any time. We believe that he does carry some residual much of the time, but the amount has been difficult to determine because of the fact that the urethral catheter quickly plugs with mucus.

At first he ate everything and seldom emptied the bladder at night. After about six weeks he developed a salty taste in the mouth and lost his appetite. Blood studies showed a mild hyperchloremic acidosis and hypopotassemia. This has been corrected by giving a small dose of sodium bicarbonate and potassium citrate once daily. He now always gets up once, and usually twice, at night. He takes a full diet except for the use of salt at the table. His bowel function is entirely normal. His sex life, which was normal before surgery, has remained unchanged, except that on ejaculation the semen now passes into the new bladder, thus rendering the patient functionally sterile.

He returned to work at his original job in an automobile factory four months after his first operation. For several months he put in from 8 to 10 hours a day, and to date has lost no time on account of illness.

Fig. 10.—Appearance of the abdomen four and one-half months after the initial operation.

CONCLUSION

We do not propose that this procedure is the perfect solution of the problem of replacing the urinary bladder after complete cystectomy, but thus far it appears to be a satisfactory solution of the problem in this case.

1066 Fisher Building.

DISCUSSION

DR. J. DEWEY BISGARD, Omaha: I am delighted to hear this case report by Dr. McLean because for some time I have wanted an opportunity to carry out this procedure in a case, but I have

never been able to convince the urologists that they should turn over a suitable case to me.

I might go back and review the experimental studies that I carried out several years ago.

[Slide] I carried out a similar type of procedure in some dogs, but it was carried out in two stages. The segment of bowel was isolated at the first procedure and the ureters transplanted to this segment of distal sigmoid. At the second procedure the bladder was removed and this isolated segment anastomosed to the urethra and then the bowel closed that is the proximal colostomy carried out at the first procedure.

[Slide] This shows the control that the animals had of the bladder. A dump pan below the cage in which the urine accumulated dropped a writing arm and enabled us to record the periods when urination took place and the quantities. These show roughly the amounts as you would read them on this record. They were able to retain urine and seemed to have good control.

[Slide] We carried out some pharmacological studies which merely showed that this segment did not change its character; that is, it performed as does the bowel to drugs, and also histologically even two years later there had not been any metamorphosis. It continued to have the histological picture of bowel.

We carried these animals along, three of them, for a two-year period, and they showed no evidence of kidney damage at the end of that time. This is one of the specimens two years later. They had normal-appearing kidneys and normal-appearing ureters. This is the segment of bowel, the artificial bladder, with the urethra.

I want to commend Dr. McLean on a very nice case report and a rather brilliant result.

DR. ARTHUR DEBOER, Chicago: Dr. McLean deserves real commendation on this masterpiece of surgery. We have similar problems in a different manner in children with urinary incontinence, particularly with those who have spinal bifida or congenital anomalies of the urinary tract. We should like to present at this time a problem that faced the parents of a child and the physician as well.

It was a youngster born with numerous congenital anomalies and a common cloaca. The rectum was transferred posteriorly with an anal orifice, and the urinary bladder and mucosa of the vagina were in continuity, so that the child had a continual urinary dribble. An occasional fecal contamination in the underclothes is distressing, but a 24-hour discharge of urine is certainly a perplexing problem.

We have toyed with a great many different ideas in trying to solve this problem of children, and, probably because the parents of this youngster refused permission to tamper with the rectum any further, we had to devise some separate type of urinary transfer. The idea was entertained of utilizing the terminal ileum as an artificial bladder, transplanting the ureters into the ileum, which certainly is not orignal, and then using the ileostomy bag. The youngster underwent an exploratory procedure, and the terminal ileum was utilized to about 15 cm. The proximal end was closed and was anchored just below the ligament of Treitz posterior to the small-bowel mesentery. The right ureter was transplanted into the distal third of the segment and the left ureter into the middle portion of the segment of the ileum.

The ileum was then brought out through the abdominal wall in a stab wound through the right rectus muscle, and an ileostomy was established with the segment of ileum being used as the bladder. The continuity of the ileum was then reestablished in an end-to-end fashion, and the child did very well. Two weeks postoperatively the bladder was completely removed.

[Slide] This shows the terminal ileum as it lay across the abdomen, and the intravenous pyelogram shows relatively normal ureters on both sides. This is an ordinary Rutzen ileostomy bag that is now used as a receptacle for the urine. The interesting thing is that the parents are now most appreciative of this procedure, because now the child can wear ordinary clothes and can go to an ordinary school.

DR. R. K. GILCHRIST, Chicago: I want to congratulate Dr. McLean. He has made a most significant contribution. Perhaps eventually the pathologists and the urologists will be able to decide which of these will eventually become carcinomatous; because of the difficulty in deciding which will become malignant, too many bladder tumors are cauterized. This procedure may encourage excision of the precancerous lesions. This offers one real solution.

We have had some experience with this problem, and either my resident or I have now had 34 patients in whom we have constructed a substitute bladder such as we have reported before. All of these patients are continent. None wears a bag.

[Slide] To have continence you must have three or four things. First of all, the cecal pouch must be the span of my hand—8½ in. That will allow 500 cc. of urine without any difficulty. The terminal ileum is not more than 4 to 5 in. long. The continuity is reestablished. The ureters are brought in from behind.

[Slide] This is a Coffey I implantation.

[Slide] We found, as you did, Dr. McLean, that these patients do not reflux urine up the ureter. That is true in almost all of these 60-odd ureters. There are only two or three that have refluxed urine up the ureters; so we have unwittingly

established a new competent ureteral vesical valve, just as is present in the normal. We fix the cecum to the tissues of the posterior abdominal wall. I believe that is the thing that makes them competent and the fact that those ureters are almost exactly like the trigone. They are fixed in back, they don't move, and when pressure is exerted you can put dye in the pouch and no dye will reflux up the ureters, except in two or three ureters in the whole group of patients.

[Slide] When you are through you can put a cystoscope through here, and if you wish you can dilate or do a meatotomy on these ureters if they are strictured.

It might be interesting for a moment to see what happened to these cases. There were three who died within 18 months; these deaths are all from carcinomas. More of them have been for infiltrating bladder carcinomas than have been for cervical and uterine carcinoma. We have alive today one woman 48 months after operation. She is continent, with no chemical imbalance and no limitation of diet.

These people simply slip a catheter through this ileum stump. They don't even sterilize it. Many of them simply stick the catheter under the faucet and put it back in a little plastic bag. The urine is clear. The trouble with the mucus is the same. One woman has lived 36 months. She is the only one who lost a kidney. I think she probably has recurrent tumor, because, having been perfectly well, she suddenly had death of the kidney without any symptoms.

A school teacher has had this artificial bladder for 35 months, and nobody knows he has any trouble. Another man of 32 is a traveling selesman.

Another man is 25 months postoperative, perfectly continent, a salesman selling across a counter in a downtown store, and nobody knows he has any trouble. A woman whose name you would recognize, who is quite active socially is now 15 months postoperative.

Two postoperative deaths occurred in the first group. One of the patients, who had had 37 transfusions before I saw her died of homologous serum jaundice. She had a perfectly normal bladder. Another had only one kidney, and we had trouble with that. There were no postoperative deaths in the last 20 cases.

Apropos of your story, the last patient is a doctor of 69, who had a bladder cancer that has been fulgurated a number of times. He is fat, but when we took out his bladder and prostate we found not only that he had this still limited carcinoma of the bladder but that he had a carcinoma of the prostate that nobody knew anything about.

Chemical imbalance has been of no trouble to us, except when the patients had recurrent carcinomas. We have had a couple of minor disturbances. The fact that the patients have no reflux up these ureters when they are implanted much as you do it with a fixed segment, or as we do it, is a very important thing and offers a good deal of hope for the long-time survival of patients who have such operative procedures. I believe this is a very nice contribution.

DR. D. W. MCLEAN, Detroit: I wish to thank Drs. Bisgard, DeBoer, and Gilchrist for their very fine discussions. I am particularly pleased to have Dr. Bisgard open the discussion, because it was his work in 1943 that first got us thinking about trying to hook up the urethra with the artificial bladder.

I appreciate very much hearing Dr. Gilchrist's remarks. I have followed his work closely and admire it very much. If we have infiltrating carcinoma, certainly his is the operation to do. There is a very strict limitation to the indications for the one that I have described.

The procedure which we have described is indicated for inflammatory lesions, for multiple recurrent benign neoplasms, and for preinvasive carcinoma of the urinary bladder. Total cystectomy is curative in these cases, and the construction of a bladder from rectosigmoid restores essentially normal function.

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Experiences with Radioactive Chromic Phosphate in Urological Tumors

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Interstitial injection of radioactive isotopes has provided the urologist with a new approach to the treatment of advanced urological tumors. Radioactive colloidal gold (Au^{198}), reported by Flocks,* was the first isotope employed in far-advanced cancer of the prostate. Some investigators, using radioactive colloidal gold, have noted undesirable complications, such as radiation ulcer of the rectum or urinary bladder and depression of the hemopoietic system from the radiation of gold.[198] Experience with x-ray, radium, or radon-seed gamma radiation has shown damage to adjacent benign tissues. The fact that gamma or x-ray radiation cannot be confined within the tumor area has made most radiation therapists reluctant to treat urological cancers by this means. Thus, the question naturally arises, would a pure beta-emitting isotope, interstitially injected, provide local tumorcidal radiation without serious widespread reaction in the normal tissue (Table 1).

Chromic phosphate ($CrPO_4$) containing radioactive phosphorus ^{32} was selected for study. As Table 1 indicates, radioactive phosphorus emits only beta radiation. The energy of the beta particles from P^{32} is greater than that of the beta component of radioactive gold. This affords a distinct advantage in the treatment of tumor masses, due to the increased penetration of the tumorcidal beta radiation. The maximum penetration of the beta particles from P^{32} is approximately 8 mm. in tissue; the major portion of the radiation dose is delivered to the 2 to 3 mm. of tissue immediately adjacent to the depot of $CrP^{32}O_4$ (Fig. 1).

For effective treatment of tumors with beta radiation, the entire tumor mass must

Submitted for publication May 23, 1955.

Read before the American College of Surgeons' Surgical Forum, Atlantic City, Nov. 15-19, 1954.

Aided by Grants from the Bay District Surgical Research Fund, the Fund for the Advancement of Urology, and the U. S. Public Health Service.

From the Departments of Surgery (Division of Urology) and Radiology and the Atomic Energy Project, University of California at Los Angeles, and the Wadsworth General Hospital, Veterans Administration Center.

* References 1 and 2.

TABLE 1.—*Physical Characteristics of Radioactive Phosphorus and Gold*

	Phosphorus	Gold
Maximum energy of emitted beta ray	1.71 mev	0.97 mev
Gamma-ray energy	None	0.411 mev
Range of beta ray of maximum energy in tissue	8.0 mm.	4.0 mm.
Volume of sphere of radius equal to maximum beta-ray range	2.14 cm.^{3}	0.27 cm.^{3}
Average energy of emitted beta ray	0.695 mev	0.32 mev
Range of particle of average energy	3.2 mm.	0.069 mm.
Volume of sphere of radius equal to average energy range of beta ray	0.137 cm.^{3}	0.003 cm.^{3}
Dosage delivered to 1 gm. of tumor tissue by 1μc. of Isotope in rep over total decay [2]	885 rep/μc/gm.	76 rep/μc/gm.
Number of microcuries deposited in 1 gm. of tissue to derive 88,500 rep over total decay	100	1092
Half-life	14.5 days	2.7 days
Particle size	0.25 to 0.5μ	0.2002 to 0.007μ

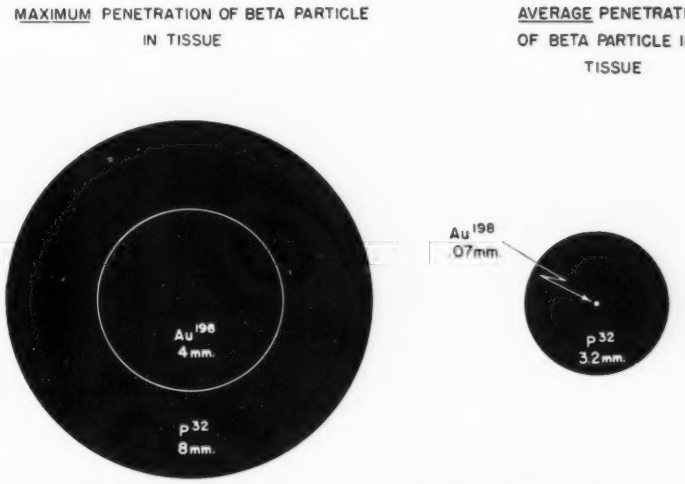
MAXIMUM PENETRATION OF BETA PARTICLE IN TISSUE
AVERAGE PENETRATION OF BETA PARTICLE IN TISSUE
Au 198 4 mm.
P 32 8 mm.
Au 198 .07mm.
P 32 3.2 mm.

Fig. 1.—Relative penetration of beta particles of radioactive gold and radioactive phosphorus.

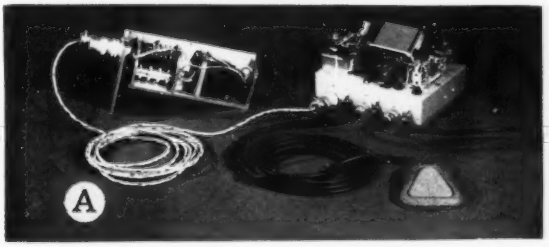

Fig. 2*A*.—Injector controls and motor pump assembly.

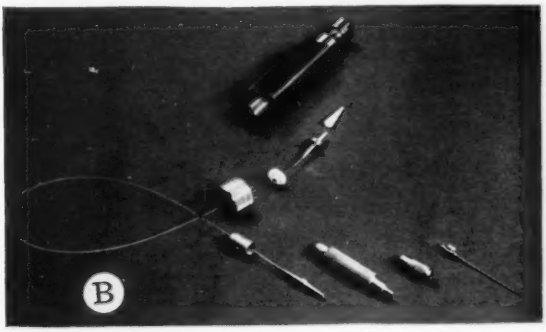

Fig. 2*B*.—Carefully machined piston pump, block, and needle tubing.

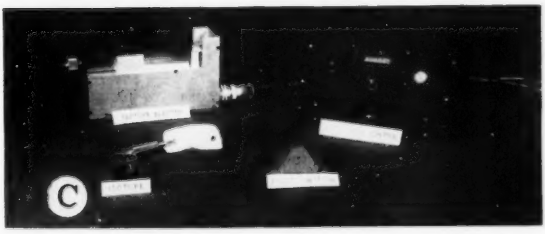

Fig. 2*C*.—Assembled injector.

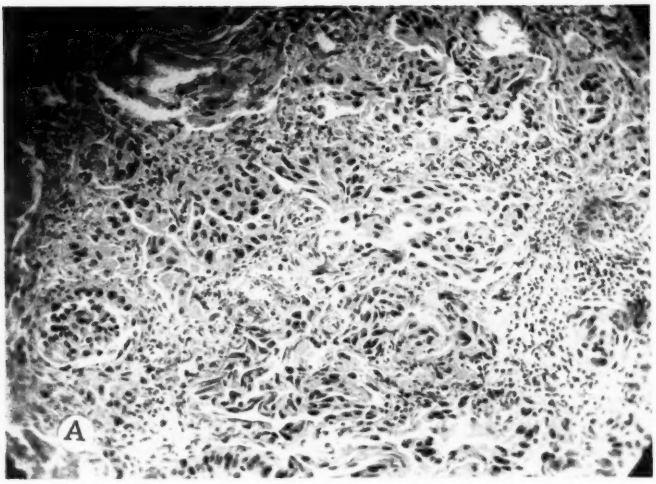

Fig. 3A.—Preinjection biopsy specimen, showing typical Grade 3 transitional bladder cancer with muscle invasion.

be uniformly infiltrated with the isotope. Preliminary animal studies suggested little or no diffusion of the $CrP^{32}O_4$ beyond the injection site. In prostates no more than 0.1 to 0.2 ml. of solution can be injected per gram of tissue. It is extremely difficult to inject with any degree of accuracy such small amounts of solution with a hand syringe, and injection patterns were not reproducible. In order to eliminate these two problems, an electrically driven and electronically controlled isotope injector was designed and built (Fig. 2A). The isotope injector includes among its components a stainless steel piston pump machined to a tolerance of less than 30 millionths of an inch (Fig. 2B). The isotope is delivered to the tumor through stainless steel tubing and couplings which permit extremely flexible manipulation of the needle, much like an electric cautery tip. The electrically driven pump has electronic controls which meter exact quantities of isotope delivered (0.1 or 0.2 ml.) with each touch of the convenient foot switch, and the total number of injections is automatically recorded (Fig. 2C). This

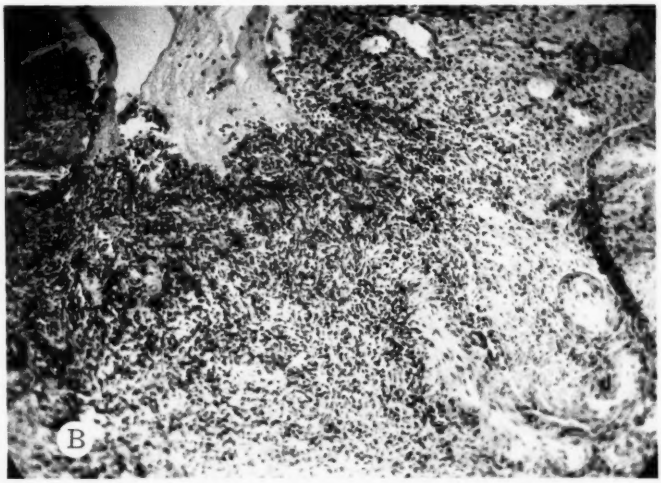

Fig. 3B.—Biopsy specimen from injection site 19 weeks after interstitial radioactive chromic phosphate treatment.

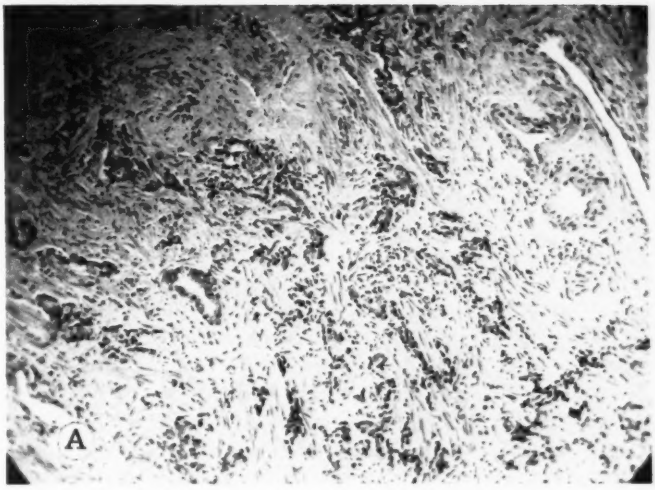

Fig. 4*A*.—Preinjection biopsy specimen of adenocarcinoma of the prostate discovered five years prior to this biopsy during suprapubic prostatectomy.

electric injector will introduce exact, predetermined volumes of isotope solution into the most impenetrable tumor tissue with ease and safety to all concerned.

A nominal dose of 100μc. of P^{32} as chromic phosphate in 0.1 ml. volume is injected in each gram of tumor tissue. This dose of 100μc. of P^{32} will theoretically deliver 88,500 equivalent roentgens to each gram of tumor tissue around it.

Using radioactive chromic phosphate, palliative treatment of far-advanced, surgically incurable bladder and prostate cancer was begun in March, 1953. Since then 45 patients have been treated. Four of these have had repeat injections (Table 2).

TABLE 2.—*The First Forty-Five Patients Treated with* P^{32}

	Living	Dead	Repeat Injections
Bladder	10	15	3
Prostate	16	4	1
Totals	26	19	4

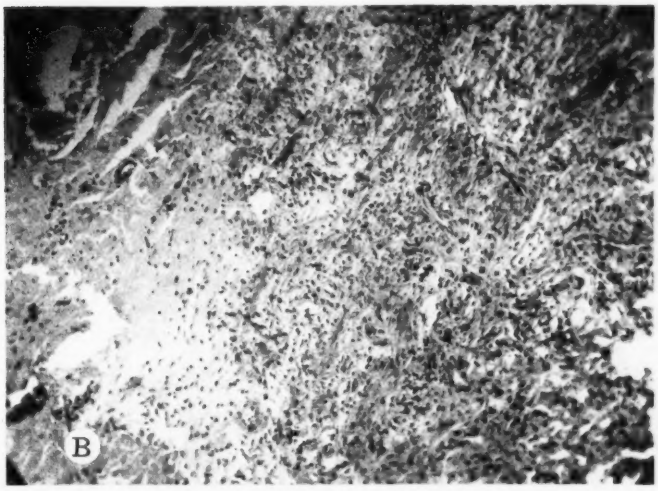

Fig. 4*B*.—Transurethral biopsy specimen of prostate six months after interstitial injection with radioactive chromic phosphate.

Preoperative study included fresh transurethral biopsies and bimanual pelvic examination under anesthesia. Blood, bone marrow, and liver function studies, as well as bladder capacity checks, excretory urograms, and cystograms, were made. Similar studies were done at 3, 6, 9, 12, and 18 months after injection. All patients have been followed closely, and autopsies were obtained on 14 of the 19 who died.

Following isotope injections, transurethral biopsies of four bladder cancers have shown benign tissue in the previous areas of deep carcinoma (Fig. 3*A* and *B*). Seven advanced prostatic carcinoma biopsies revealed no evidence of tumors in the biopsy sites. Other biopsies after injection have shown marked cytological changes in the areas of injection (Fig. 4*A* and *B*).

There were no ill effects after isotope injection. No suprapubic fistulae developed after the 43 transvesical injections. The one patient receiving injection perineally had perineal leakage through an irradiation fistula until his obstructing prostatic tissue was resected.

Careful liver tests, bone marrow assays, and blood counts have failed to demonstrate damage to these tissues after interstitial injection.

Bladder capacity studies before and after isotope injection have shown a temporary 20% to 40% decrease in comfortable capacity immediately after suprapubic cystotomy. There have been no instances of the contracted postradiation bladder.

Advanced prostatic cancer cases have shown marked local shrinkage of the tumors after interstitial isotope injections. It has been impossible, however, to inject the isotope in all of the cancer extending beyond the prostate. The problem of locating tumor extension is also complicated by the technical difficulties of accurately introducing the potent isotope into the tumor extension. Interstitial injection of radioactive chromic phosphate into prostatic cancer does not produce irritative symptoms. These patients actually note relief from mild obstructive and minimal irritative symptoms after treatment.

Patients with far-advanced, bleeding bladder cancers seem to derive greater benefit from interstitial irradiation. There is gratifying relief of irritative symptoms, spasm, and bleeding within two to three days after injection. This relief continues for up to 18 months after injection, even though the tumor extensions which could not be reached for injection may kill the patient. Some patients with severe pain returned home for weeks or months without their former heavy doses of narcotics. Frequent bladder irrigations or fulgurations were no longer needed. Autopsies have shown local suppression of tumor growth.

When uniformly injected, a dose of 100μc. of radioactive chromic phosphate per gram of tissue will exert marked radiation effect on cancers of the bladder and prostate. This dose gives definite and safe relief of bladder irritative symptoms incident to such far-advanced urological cancers. No evidence of damage to the rectum, bladder, or bone marrow (such as has been reported with gold ^{198}) has been observed in our patients. Better distribution of interstitially injected isotopes is now the most fundamental problem to be solved.

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Volvulus of the Cecum and Sigmoid Colon

An Analysis of Nine Cases

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and
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GENERAL CONSIDERATIONS

Volvulus is the cause of approximately 10% of large-bowel obstruction in the United States. It occurs most frequently in the sigmoid flexure, less often in the cecum and small intestine, and rarely in the transverse colon or stomach. Prompt recognition and proper treatment of volvulus are important for the following reasons: (1) The recurrence rate is high, and the economic drain on patients forced to undergo repeated hospitalization and noncurative operations is great. (2) With each attack there is an inherent danger of strangulation which is associated with an astonishingly high mortality of from 40% to 60%.* (3) Proper surgical correction practically assures a cure. The high mortality in volvulus is due largely to a failure to recognize the condition until complications are present, to ill-advised conservative measures which do nothing to effect a cure and can be dangerous, or to an attempt to do too much in the presence of a severely distended or gangrenous bowel.

Early diagnosis and proper surgical treatment depend on the recognition of two fundamental abnormalities present in these cases. These are (1) a segment of redundant, mobile bowel and (2) a point of fixation about which torsion may take place. Such a mechanism logically explains the dynamic pathology that results, the diagnostic inferences that should be made, and the therapeutic measures that should be employed.

Nine cases of volvulus (Table) which illustrate a certain uniformity of complaints, physical findings, and radiologic findings which should lead to an early diagnosis are used for this article. These cases were unusual from several aspects. The average age was 40, which is much younger than the usual age cited for volvulus. Six cases were of the cecum and three were of the sigmoid, which is the reverse of the usual incidence. Of greatest interest was the multiplicity of noncorrective and inappropriate surgical procedures that previously had been employed. In each case except one the pathologic state was found to lend itself readily to a corrective procedure, which, on follow-up ranging from a few months to years, has been found curative. There was no mortality associated with the treatment of these nine cases.

ETIOLOGY

The basic requirements for a loosely attached, redundant bowel and a point of fixation for torsion are provided by certain embryological deviations that may occur in the developing gastrointestinal tract. Anatomical studies † have shown that 10% to 13% of persons have a mobile cecum which is capable of undergoing torsion. This mobility results from a failure of proper attachment of a varying length of cecum and ascending colon during the last stages of intestinal rotation and fixation.[8] It is sur-

Submitted for publication Aug. 18, 1955.

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* References 5, 7, and 14.

† References 8, 11, and 15.

Clinical Data in Nine Cases of Volvulus

Case	Age, Yr.	Race	Sex	Previous Attacks	Previous Surgery	Symptoms				Findings				Site	Surgery
						Pain	Colic	Vomiting	Flatus	Distention	Tenderness	Bowel Sounds	Mass		
1	35	W	M	None	None	+	+	+	0	+	+	+	0	Cecum	Cecopexy
2	57	W	F	Numerous	Appendectomy	+	+	0	+	0	0	+	+	Cecum	Cecopexy
3	58	W	M	3	2 explorations for bowel obstruction: 1. derotation; 2. cecostomy	+	+	+	0	+	+	+	+	Cecum	Cecopexy
4	38	W	F	Numerous	1. Appendectomy; 2. cholecystectomy; 3. excision of rt. tube & ovary	+	+	+	0	+	0	+	0	Cecum	Cecopexy
5	42	W	F	Numerous	1. Appendectomy; 2. cholecystectomy; 3. excision of rt. tube & ovary; 4. exploration for adhesions	+	+	+	+	+	0	+	+	Cecum	Cecopexy
6	21	N	F	6	2 explorations for "twisted bowel"; derotation	+	+	+	0	+	+	+	0	Cecum	Cecopexy
7	31	N	M	None	None	+	+	+	+	+	+	+	0	Sigmoid	Derotation
8	35	W	M	1	1 exploration for "twisted bowel"	+	+	+	0	+	+	+	0	Sigmoid	Obstructive resection
9	56	W	F	4	1 exploration for lysis of adhesions	+	+	+	0	+	+	+	0	Sigmoid	Obstructive resection

prising from these figures that volvulus of the cecum is not commoner, and it is certain that many cases go unrecognized. Similar anatomical studies of the sigmoid colon have not been reported, but it must be assumed from clinical observation that at least the same percentage of persons have a redundant sigmoid colon capable of undergoing torsion, since the incidence of sigmoid volvulus is twice that of cecal volvulus. Certain racial and geographical groups have a high incidence of sigmoid volvulus, which accounts for 30% to 50% of all intestinal obstruction.‡ Barium studies have shown that the redundancy is present at an early age, which substantiates the congenital rather than acquired nature of the condition. Congenital variations are less common in the transverse colon, and volvulus here is rare because of the normally wide attachment of the mesocolon and the wide separation of the major points of fixation.

Once the basic requirements for the formation of volvulus are present, the initiation of the pathologic process frequently is dependent upon or associated with certain precipitating factors.§ Among those mentioned are diet, constipation, increased intestinal motility (purgatives, lead poisoning), adhesions, tumors, fecaliths, position, exertion, trauma, and pregnancy. The only association noted in our nine cases was the effect of body position. In two patients with cecal volvulus, lying on one side greatly aggravated the pain, while one patient with sigmoid volvulus found the knee-to-chest position to give partial relief of cramps.

PATHOLOGY

In volvulus of the cecum, obstruction may occur when the bowel doubles upon itself along either an oblique or a transverse axis (Fig. 4) or when torsion along a longitudinal axis occurs. The method depends largely on the type and point of colon attachment. In either instance chronic recurring volvulus may result. A transverse crease above the ileocecal junction at the lowest point of attachment of the bowel was found in four of our six cases. Three of these had many previous attacks of pain in the right lower abdominal quadrant, while in the fourth case volvulus was recognized during the initial attack. In two cases a variable amount of terminal ileum and ascending colon was free to enter the torsion, which took place along a longitudinal axis. Each of these patients had had two previous attacks which eventuated in surgical exploration.

In sigmoid volvulus, the usual mechanism consists of distention of the distal, or rectal, limb of the loop, which progresses upward and comes to cross anterior to the proximal, or colonic, limb[13] (Fig. 5). In our three patients with sigmoid volvulus, one had 270 degrees of rotation and one had 360 degrees. The third patient was operated upon between attacks, and no torsion was present. In either cecal or sigmoid volvulus the terms clockwise and counterclockwise rotation probably do not convey a uniform impression and should be discarded.[2] Through clinical experience it has been found that the severity of circulatory embarrassment is governed more by the tightness of the twist than by the number of turns.[4] First the venous return is impeded, and later the arterial blood supply becomes deficient. Transudation of blood into the lumen and into and through the bowel wall occurs, followed by infarction, gangrene, and frank perforation. Once this stage is reached, the fatality rate becomes excessive, regardless of the treatment employed.[5] A closed-loop obstruction is produced, which in the beginning may be incomplete or intermittently complete, allowing intestinal peristalsis to force air into the loop as it becomes closed. This mechanism, plus diffusion and fermentation of gases, may result in enormous distention. If the ileocecal valve is competent, a double closed-loop obstruction may be produced which may simulate other forms of large bowel obstruction because of distention proximal to the involved area. However, the greatest amount of distention will be found in the twisted loop.

‡ References 1, 3, and 7.

§ References 3, 4, and 6.

DIAGNOSIS

Clinical.—It is surprising that misdiagnosis is so common in either cecal or sigmoid volvulus, since careful attention to the clinical and radiological findings should lead to an early diagnosis in the majority of instances. In general there are two clinical groups of patients[9]: (1) those with an acute attack, usually the first or second episode, comprising about one-fourth of cases, and (2) those with a long history of repeated attacks of varying severity. In the former group the patients usually are younger and, as in two of our cases, one cecal (Case 1) and one sigmoid volvulus (Case 7), relate a sudden onset of cramping abdominal pain of short duration before seeking medical attention. In each case, pain was localized to the side of involvement and early reflex nausea and vomiting were present. After the onset of symptoms, passage of gas and feces was absent in the patient with sigmoid volvulus and greatly reduced in the patient with cecal volvulus. The abdomen was distended, and tenderness was present on the side of involvement. Rectal tenderness was present. In each case there was elevation of the pulse, temperature, and leucocyte count. As with both these cases, surgical treatment is usually undertaken early because of the clear-cut clinical evidence of intestinal obstruction, although the exact diagnosis may not be suspected preoperatively.

In the second group—those with recurrent attacks—the patient frequently presents a variable clinical picture, depending on the severity of a given episode. Frequently, there is a long history of many attacks, some regressing spontaneously and others necessitating hospitalization. There may be any degree of abdominal colic, distention, and vomiting. Abdominal tenderness is frequently absent, and fever, rapid pulse, and leucocytosis are uncommon unless complications are present. Occasionally, a mass may be palpable, as in three of our cases (Cases 2, 3, and 5), and visible peristalsis may be seen where chronic obstruction is present, as in one patient (Case 3). This second group is the one in which the diagnosis is frequently overlooked because of the variable clinical findings and a failure to attach proper significance to the history of repeated bizarre attacks of abdominal pain seemingly unrelated to anything. Seven of our nine cases (five cecal, two sigmoid) were in this group, and each patient had averaged four to five attacks requiring hospitalization, as well as other attacks of less severity, some "too numerous to count," which had regressed spontaneously. In this group there was a total of 14 previous operative procedures which could be related to previous attacks. One patient (Case 5) with recurrent attacks of pain due to volvulus of the cecum had been subjected previously to cholecystectomy, appendectomy, excision of the right tube and ovary, and one exploration for intestinal adhesions, at four separate operations. Another patient (Case 4) had cholecystectomy, appendectomy, and excision of the right tube and ovary, and a third patient (Case 2) had an appendectomy; all were performed during separate attacks of abdominal pain. These are examples in which the disease went unrecognized even at surgery, and in no case was there relief of symptoms after surgery. In four other cases, two cecal (Cases 3 and 6) and two sigmoid (Cases 8 and 9) volvulus, six explorations for intestinal obstruction had been performed previously, but in no case was anything done except derotation, proximal decompression, or cecostomy. These are examples in which the diagnosis was recognized at surgery, but a curative procedure was not accomplished.

Analysis of these nine cases (Table) and of other series‖ shows that there is a certain uniformity of symptoms and signs that are either present during an attack or can be elicited by a careful history as having been present during previous attacks. In every one of the nine cases the history of pain of a colicky nature and abdominal enlargement of some degree could be elicited. Nausea and vomiting were present in all but one

‖References 2, 3, and 7.

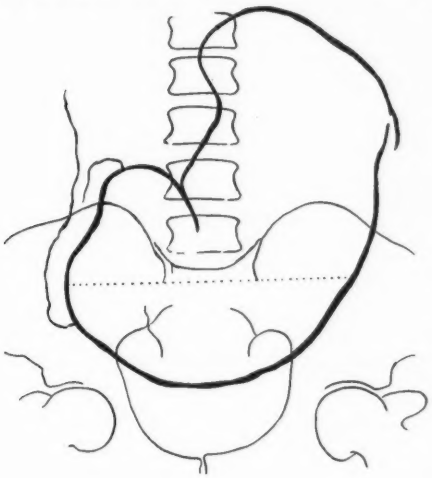


Fig. 1 (Case 3).—Volvulus of the cecum. *A*, the distended cecum usually occupies a position in the upped abdomen. *B*, note the single fluid level in the distended loop. The separate air bubble in the stomach excludes the possibility of gastric dilatation as the cause of the distention. Note also the paucity of gas in the colon distal to the obstruction.

case, and passage of gas and feces was absent after onset in five cases. In the other four cases a change in the normal bowel habit was present, especially during an attack. Occasionally, the patient may note that the end of an attack is associated with the passage of a large amount of flatus or a voluminous bowel movement. Proper attention to such details in the history and physical examination may lead to a strong suspicion of volvulus. When these data are coupled with the findings on plain radiographic films and barium study, the diagnosis should be practically certain.

Roentgenographic Findings.—The proper interpretation of plain views of the abdomen depends, first, on the ability to distinguish the gaseous patterns of small- and large-bowel distention and, second, on a knowledge of certain patterns that occur frequently with volvulus of the colon.

In cecal volvulus the involved loop frequently migrates to the upper abdomen and may assume enormous proportions (Fig. 1*A* and *B*). The appearance may simulate gastric dilatation, which can be differentiated if a separate air shadow can be seen in the stomach area (Fig. 1*B*) or by aspiration of the stomach if the air bubble is not present. Minimal small-bowel distention will be seen early but later may appear below or on the right side of the displaced cecum (Fig. 1*A* and *B*). A single fluid level is usually noted on upright films (Fig. 1*B*), and there may be some shift of the distended loop when the upright position is assumed. Gas in the

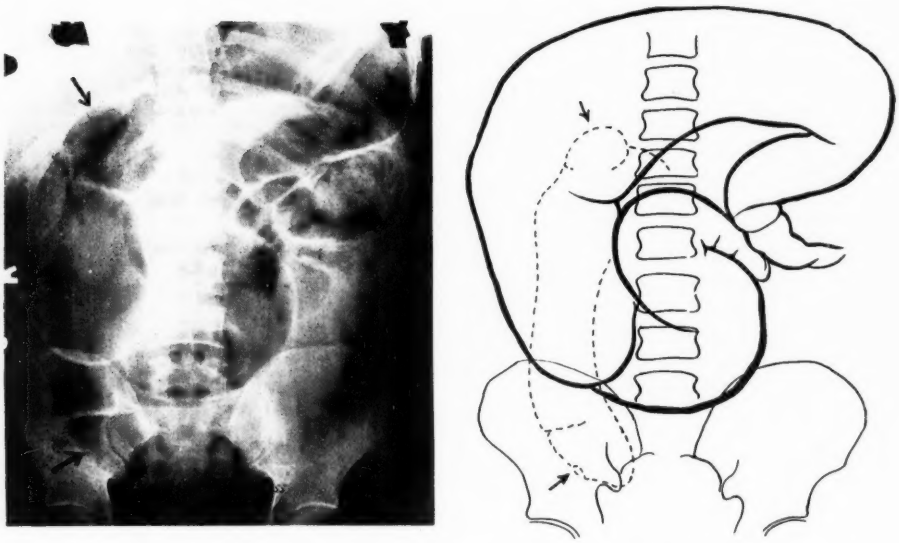
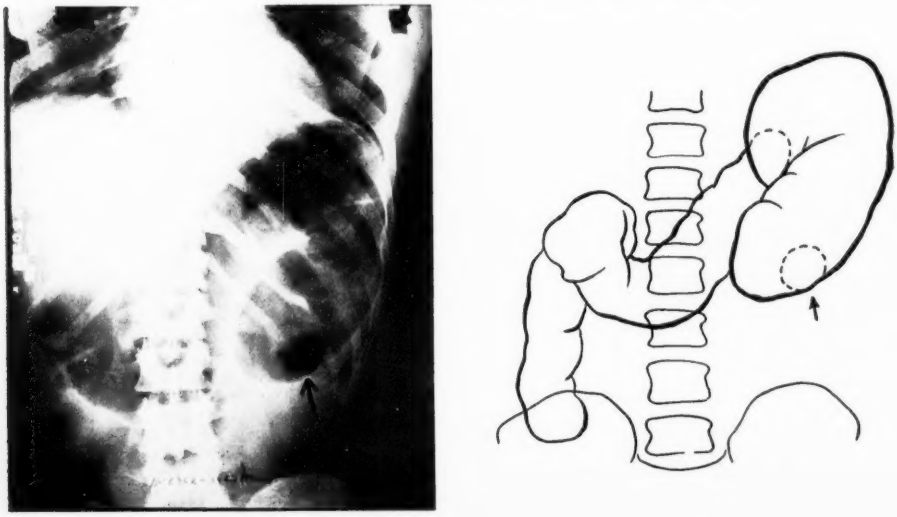


Fig. 2 (Case 8).—Sigmoid volvulus. The distended bowel fills almost the entire peritoneal cavity. The site of torsion can be seen on the patient's left side. The distended colon proximal to the obstruction is seen (arrows) behind the shadow of the sigmoid loop. Note absence of gas pattern distal to the obstruction.

remainder of the large bowel is minimal or absent.

Barium study will confirm the diagnosis when a cone-shaped obstruction of the ascending colon, with spiral mucosal folds at the point of twisting, is seen. Occasionally, twisting can be seen on plain films, but this is commoner in sigmoid volvulus (Fig. 2).

Fig. 3 (Case 7).—Sigmoid volvulus. The shadow of the distended loop of sigmoid colon is superimposed on the shadow of the proximal colon (Diagram). The point of torsion is indicated by the arrow. There is a complete absence of gas pattern distal to this point.



In general, when barium will not pass into the cecum and distention is present the diagnosis is almost certain.[4] In the absence of an acute attack, barium study with fluoroscopic manipulation will reveal an abnormally mobile, redundant cecum, usually in the depths of the pelvis. The diagnosis was established by this finding in one patient (Case 6).

In sigmoid volvulus there appears a distended segment of large bowel with a more definite loop formation than that found in cecal volvulus. The apex of this loop is most frequently in the upper or central portion of the abdomen, with the convex side on the right (Figs. 2, 3, and 5). The area on the left side of the abdomen below the sigmoid flexure is usually devoid of air (Figs. 2 and 3). The gaseous pattern of the colon proximal to the obstruction may be seen readily, superimposed on the shadow of the involved loop (Fig. 2). In the presence of strangulation and peritonitis, fluid in the peritoneal cavity and between the loops of bowel may be seen on plain films, and free peritoneal air may be noted when perforation is present. On barium enema the classic ace-of-spades or bird's-beak configuration of the distal colon is considered diagnostic. It should be remembered, however, that the ability to force barium to the cecum does not eliminate the possibility of volvulus. In such cases a valve type of mechanism may allow passage of the barium but may prevent its return.

TREATMENT

Conservative Treatment.—Since in either cecal or sigmoid volvulus a closed-loop obstruction exists, intestinal intubation for decompression obviously will be of no avail for definitive treatment, but this may be employed advantageously for the relief of vomiting preoperatively and to forestall abdominal distention in the postoperative period. In sigmoid volvulus the obstructed loop sometimes is approachable by various nonoperative measures, such as enemas, barium enema with fluoroscopy, and passage of a rectal tube guided by sigmoidoscopy. The chief disadvantages of these measures are that nothing is done to effect a cure, the presence and degree of strangulation cannot be determined, and there is danger of perforation. Even with the bowel under direct vision at surgery, perforation may occur despite the most gentle manipulation. Those who advocate the conservative approach[10] list the contraindications to its use as peritoneal irritation, rebound tenderness, decreased or absent bowel sounds, and blood in the sigmoid on proctoscopy. Complete safety may not be assured, since in the very young or the aged these findings may be notoriously unreliable as a true indication of the presence of complications or peritonitis. Conservative treatment is oftenest employed as a means of avoiding an emergency operation, allowing time for a planned procedure. Ideally, conservative therapy might be attempted in a patient who is a poor risk from causes other than volvulus, who needs extensive preparation for surgery, and in whom no signs of complications are present.

Surgical Management. — Surgical correction in either cecal or sigmoid volvulus is the treatment of choice. Two alternatives are available for the correction of the basic abnormalities previously described: (1) the resection of redundant bowel to an area of normal attachment or (2) the establishment of new points of attachment. In either cecal or sigmoid volvulus certain preliminary steps must be taken before these objectives can be obtained. They are (1) derotation and relief of any constricting bands, (2) decompression, (3) determination of bowel viability, and (4) decision as to the operative procedure best suited for the pathology present. Derotation may be hazardous in the presence of an injured bowel, and occasionally needle or trocar decompression must be done before detorsion can be accomplished safely. More frequently, derotation can be accomplished first and internal decompression done by passing a rectal tube from below, guided by the surgeon's hand above. The tube can be passed as far as necessary, and by careful manipulation the distention can be relieved.

Treatment of Cecal Volvulus.—If nonviable bowel is present, then resection and ileo-

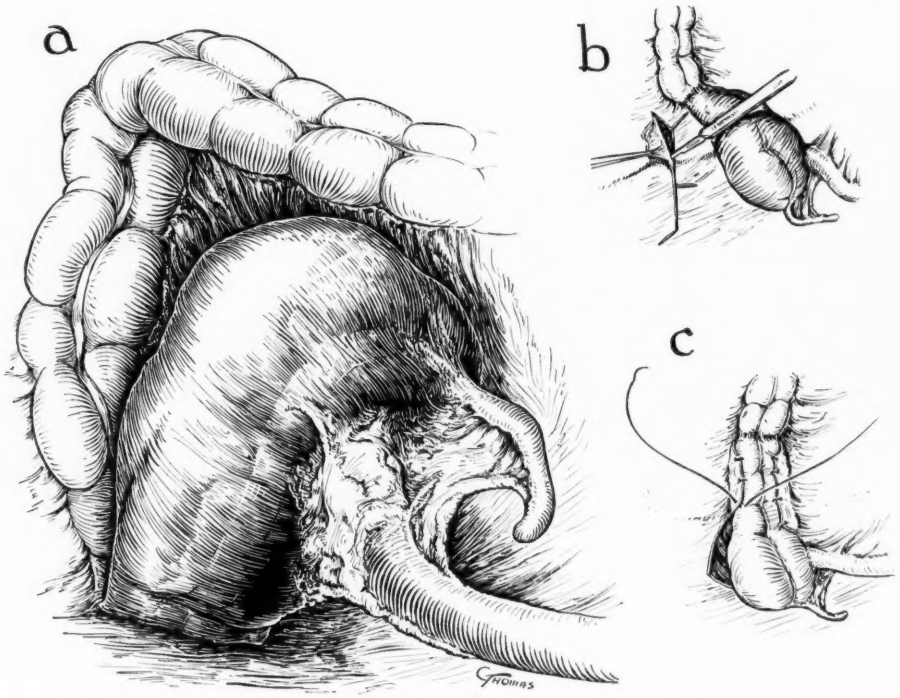


Fig. 4.—Volvulus of the cecum. *A*, volvulus has taken place at the lowest point of attachment of the ascending colon. Further torsion about the longitudinal axis is dependent upon the amount of unattached terminal ileum. *B*, derotation has been accomplished. Internal decompression can be accomplished by a gentle milking of the cecal contents distally and passage of a soft rubber tube rectally. Occasionally, needle or trocar aspiration must be done. The parietal peritoneum is slit, and flaps are dissected to prepare a bed for the cecum. *C*, fixation of the redundant cecum is completed with fine nonabsorbable sutures.

transverse colostomy are indicated. Resection has been advocated by some [12] as the procedure of choice in every case. This is somewhat radical, since cecopexy is equally effective and obviates the hazards of resection and anastomosis (Fig. 4). In the poor-risk patient with strangulated bowel, exteriorization or obstructive resection may be necessary to conclude the operation speedily, but this generally should be avoided in the cecal area. Cecostomy has been suggested as a means of decompression and fixation [4] but may not be effective in all cases, since the point of eventual attachment is so small. One patient (Case 3) had cecostomy performed during a previous attack but later had a recurrence necessitating cecopexy. At surgery the cecum showed no evidence that previous attachment to the abdominal wall had been present. If the bowel is viable, the procedure of choice is the attachment of the bowel in as near normal position as possible to the parietal peritoneum in the right lower quadrant. The development of peritoneal flaps, as shown in Figure 4, will partially retroperitonealize the cecum and will effectively prevent recurrence. This method of cecopexy was accomplished in all six cases of cecal volvulus. Follow-up study has shown that all have remained free of symptoms for periods varying from a few months to several years.

Treatment of Sigmoid Volvulus.—Because of space limitations, there is no effective means for securing new areas for attachment of the sigmoid, and resection is the only

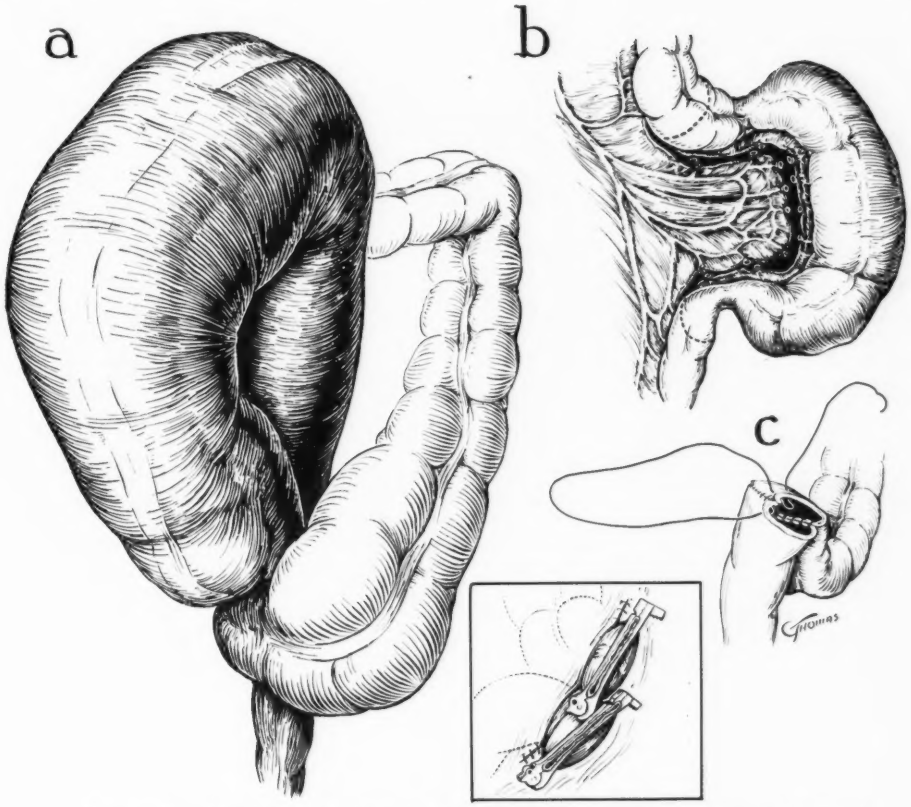


Fig. 5.—Sigmoid volvulus. *A*, the typical appearance is shown, with the enormously dilated loop of sigmoid colon occupying a position in the upper central abdomen. Vascular changes are most prominent near the site of torsion. The colonic segment proximal to the volvulus also becomes distended, while the rectal segment distal to the volvulus is collapsed. *B*, derotation has been accomplished. Closed decompression then may be done by passing a large-bore soft rubber tube from below, guided by the surgeon above. The amount of colon to be resected is indicated by the dotted lines. *C*, primary anastomosis is the procedure of choice, provided circulatory damage or a marked discrepancy in the size of the proximal and distal bowel do not make anastomosis technically hazardous. *Inset:* When primary anastomosis is dangerous, obstructive resection is indicated. The loops of bowel are exteriorized through a separate muscle-splitting incision lateral to the rectus muscle. Bowel continuity is restored 3 to 4 weeks later.

means of assuring permanent cure (Fig. 5). Primary anastomosis is safe, provided distention, edema, discrepancy in size of the proximal and distal loops, or potentially nonviable bowel do not make anastomosis technically hazardous. In these instances obstructive resection should be performed (Inset, Fig. 5). If the distal segment cannot be exteriorized, then a simple inverting closure may be done and the proximal bowel brought out as a colostomy. It is our belief that this two-stage procedure is much safer if there is any question of a precarious anastomosis. In two of our cases (Cases 8 and 9) of sigmoid volvulus, obstructive resection was done. Bowel continuity was reestablished easily three weeks later in each case. The other case (Case 7) had simple derotation performed. Postoperative complications not related to the volvulus precluded any further surgery, and the patient still has the possibility of recurrence.

In either cecal or sigmoid volvulus, simple derotation, cecostomy or other means of

proximal decompression, or cecostomy to give fixation were found to be inadequate procedures in this group of cases. The hazard of doing an inappropriate operation is shown by the fact that of six such operations in this group, five performed elsewhere and one by us, recurrences were noted in all but one, and follow-up time is still short in this patient (Case 7).

SUMMARY

The fundamental abnormality in any case of volvulus is a segment of loosely attached bowel which is free to undergo torsion about a point of fixation. This abnormality can be explained logically on a congenital basis. Such a mechanism clearly explains the dynamic pathology that may result, the diagnostic inferences that should be made, and the methods of effective treatment that must be employed.

Early diagnosis is based on recognition of the clinical and radiological findings, which in the majority of instances are sufficiently specific to allow a positive diagnosis.

The excessive mortality in volvulus is due to a failure to recognize the diagnosis until complications have occurred or to the use of conservative treatment or noncorrective operations which fail to effect a cure.

Surgical correction, consisting of fixation in cecal volvulus and resection in sigmoid volvulus, is the treatment of choice. This should be accomplished, or at least initiated, at the first operation.

This plan was found effective in the treatment of eight out of nine cases of volvulus. In the one case in which this plan was not followed, the possibility of recurrence is still present.

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Posterior Dislocation of the Shoulder

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Although posterior dislocation of the shoulder was accurately described by Sir Astley Cooper [1] in 1842, little heed was paid to this specific entity in the literature until the past few years except for isolated reports of its rarity. Between 1930 and 1940, the frequency with which the x-ray picture had been misinterpreted was pointed out by Thomas,[2] Rendich,[3] and Wood [4] and the importance of views other than the routine anteroposterior in conclusively establishing the diagnosis was stressed.

Throughout the past six years, there has been an increasing awareness of this lesion in the literature. In 1949, Wilson and McKeever [5] reported their experiences with 12 cases. In 1952, Taylor and Wright [6] and McLaughlin [7] added substantially to our knowledge of this subject, and in the past few months Dorgan [8] has contributed an excellent paper. However, it is our feeling that, as yet, too little attention has been devoted to the methods of recognition and particularly to the proper treatment of this lesion. The importance of accurate diagnosis and adequate treatment cannot be minimized because the attendant sequelae of mismanagement are marked limitation of motion and persistent pain.

Posterior dislocations of the shoulder have been classified, according to the relative degree of posterior displacement of the humeral head, as subluxated, subacromial, or subspinous in type.

The commonest causes of posterior dislocation are severe trauma to the adducted internally rotated arm or a direct blow to the anterior aspect of the glenohumeral joint and violent muscular contractions produced by shock therapy or grand mal seizure. Of our 17 cases (16 patients), 7 occurred after convulsions and 10 were the result of trauma.

Of the latter, one occurred as the result of a direct blow to the shoulder in a football game, two followed a fall from a height onto the shoulder, and seven were sustained in automobile accidents.

The characteristic clinical picture of an acute subspinous posterior shoulder dislocation is easily recognized and is most frequently over-looked because the physician is unacquainted with the lesion and has not borne the possibility in mind. The patient presents himself with his arm in a Velpeau position, the limb being held in adduction and internally rotated across the chest. There is loss of the normal oval contour of the shoulder anteriorly and globular fulness posteriorly. Frequently, one can palpate the humeral head posteriorly. Abduction and external rotation are markedly limited, and attempts at motion in these directions are painful, but the shoulder can be internally rotated without undue discomfort. Unfortunately, one is not always confronted with such a typical case, as the reactionary swelling may quickly obscure the diagnostic landmarks. Associated fractures about the humeral head and neck are frequent and tend to be misleading (Cases 8 and 9). Eight of the 16 patients in our series received incorrect diagnoses initially (Case 12). In 12 of our 17 cases there were concomitant fractures of the proximal hu-

Accepted for publication Aug. 30, 1955.

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Read before the Section on Orthopedic Surgery at the 104th Annual Meeting of the American Medical Association, Atlantic City, June 8, 1955.

Fig. 1 (Cases 8 and 9).—Bilateral posterior fracture dislocation. Treated by open reduction. Views demonstrate range of motion. Five-year follow-up.

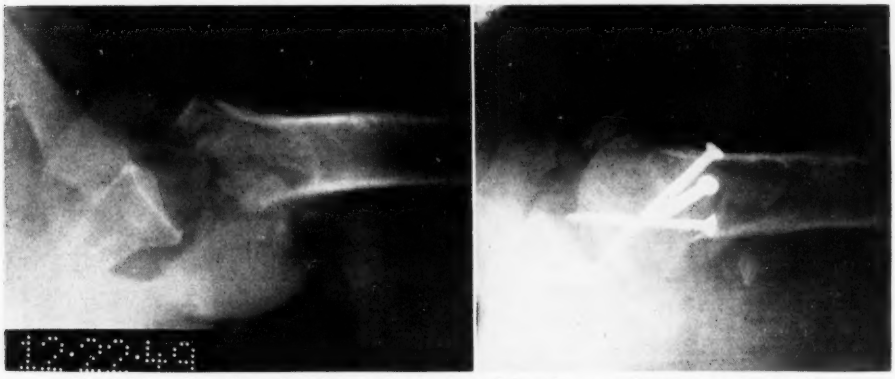
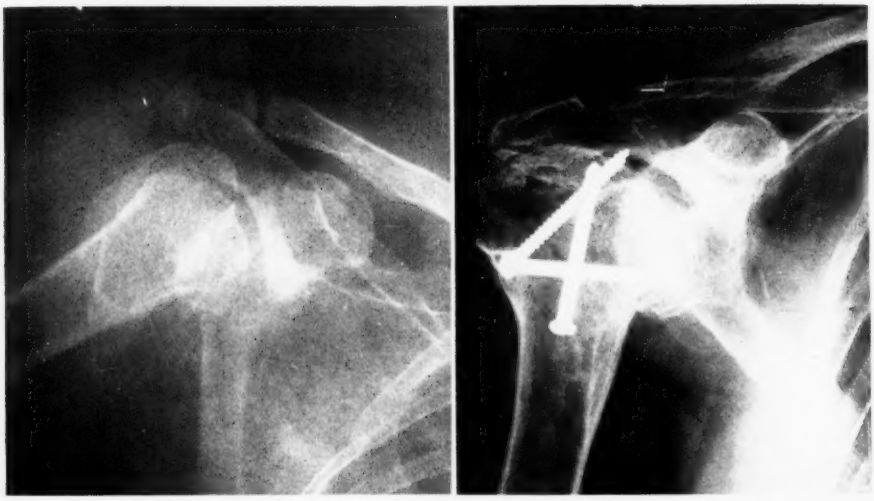


Fig. 2 (Case 8).—Comminuted posterior fracture dislocation secondary to grand mal seizure. Left, axillary view establishing diagnosis. Right, appearance five years later.

Fig. 3 (Case 8).—Comminuted posterior fracture dislocation secondary to grand mal seizure. Left, initial anteroposterior view (misdiagnosed as comminuted fracture of the head). Right, appearance five years later.



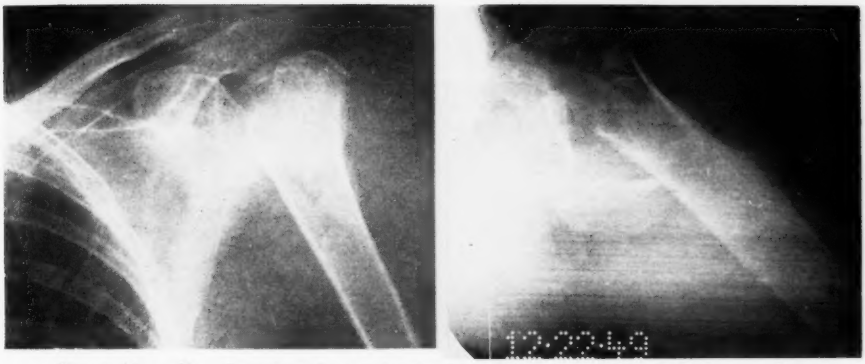


Fig. 4 (Case 9).—Comminuted posterior fracture dislocation of left shoulder secondary to grand mal seizure. Anteroposterior and axillary views one week after injury establishing the diagnosis.

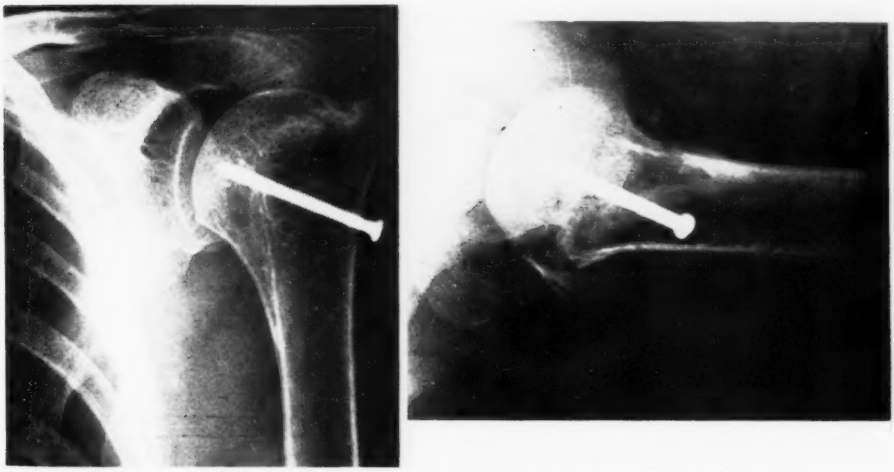
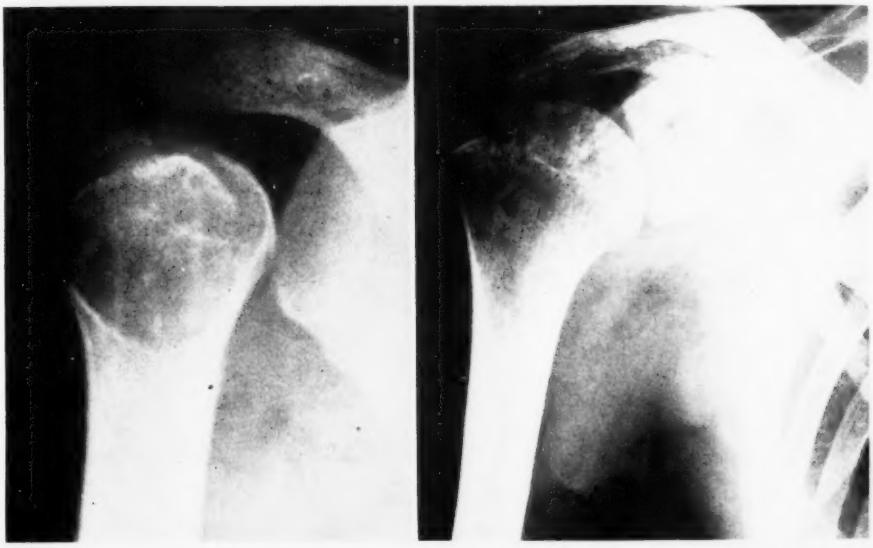


Fig. 5 (Case 9).—Appearance five years after open reduction and internal fixation.

Fig. 6 (Case 12).—Left, posterior dislocation of shoulder unrecognized for three weeks demonstrates cystic appearance of the humeral head. Right, postreduction view.



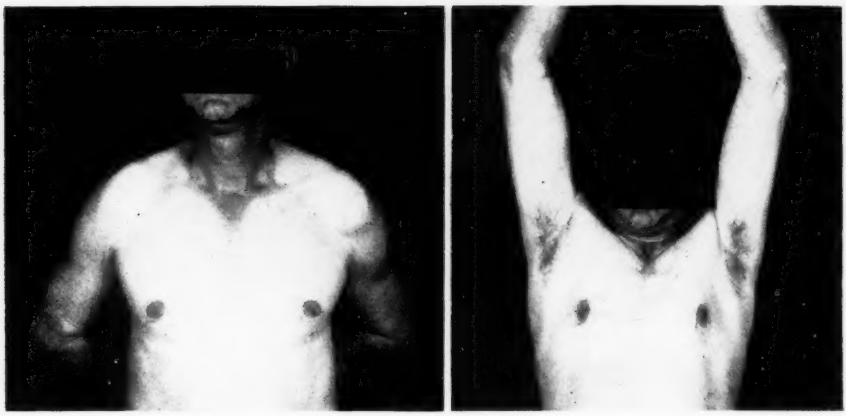


Fig. 7 (Case 12).—Posterior fracture dislocation, two-year follow-up. Views demonstrate excellent range of motion.

merus, and for 7 of these the initial diagnosis was one of fracture without recognition of the dislocation. These cases, in general, were treated with a sling or hanging arm cast and were begun on periarthritic exercises. In one case the associated dislocation was not recognized until two months after injury (Case 3). What was described as a periarthritis secondary to a fracture of the surgical neck of the humerus was, in truth, an unreduced posterior fracture dislocation which had gone on to fibrous ankylosis. This patient has a poor functional result, with limitation of active motion in all directions. It is apparent, therefore, that early accurate diagnosis is necessary to achieve satisfactory results.

Fig. 8 (Case 3).—Posterior fracture dislocation undiagnosed for two months. Fourteen-month follow-up. Fibrous ankylosis with functional disability.

X-ray, of course is essential to establish the diagnosis. The various diagnostic features of posterior dislocation on the anteroposterior view (1) exposure of the inferior one-third of the glenoid fossa (Case 16) and (2) rotation of the lesser tuberosity so as to be brought into profile medially, are well recog-

Fig. 9 (Case 3).—Roentgenogram of Feb. 25, 1954. Diagnosed as comminuted fracture of the humeral head.

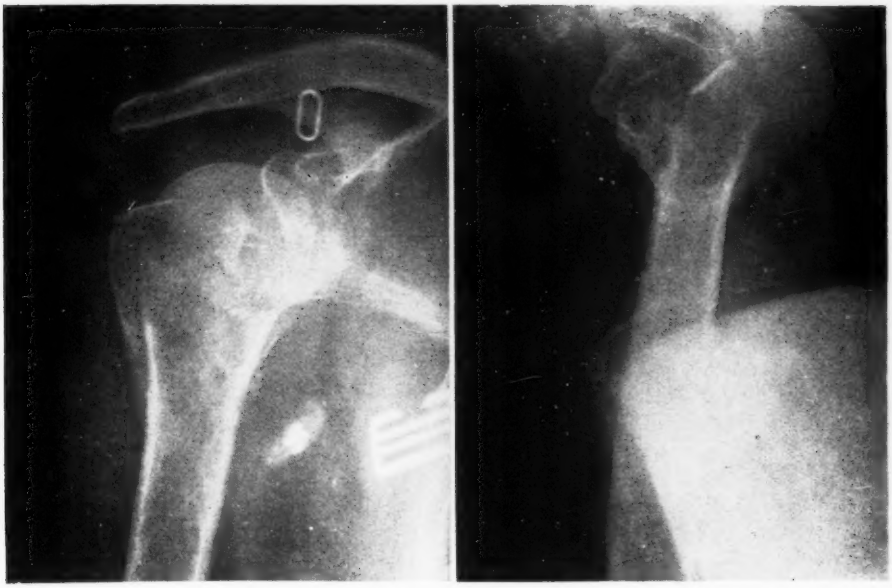


Fig. 10 (Case 3).—Diagnosis of posterior dislocation by axillary view two months after injury.

Fig. 11 (Case 3).—Appearance on April 25, 1955. Persistent posterior dislocation.

nized. In our review of x-rays, we have been impressed with the cystic or hollow appearance of the humeral head (Case 1) with posterior dislocation in the anteroposterior plane and have used this as a reliable index to obtain diagnostic views. Occasionally, one sees an overlapping of the humeral head and glenoid (Case 2). Also, on transthoracic films we have noted, as has Dorgan,[8] that there was an interruption of the normal scapulohumeral arch formed by the axillary scapular margin and the inferior border of the neck and shaft of the humerus (Case 1). The important fact to bear in mind is that anteroposterior views alone are insufficient, except for the experienced roentgenologist in most instances, and axillary, transthoracic, or oblique views should be utilized to confirm the diagnosis. It is particularly important always to bear in mind the possibility of posterior dislocation whenever one sees a fracture about the head or neck of the humerus and to take appropriate x-rays.

In reviewing the pathological findings in acute posterior dislocations, one is impressed

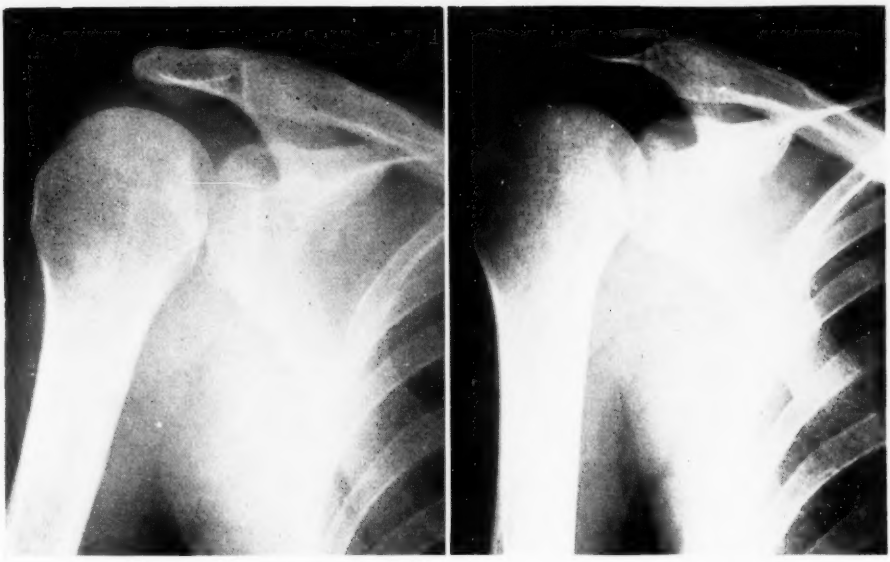


Fig. 12 (Case 16).—Head of humerus posterior and reduced, demonstrating defect in anterosuperior margin of head (one dislocation).

Fig. 13 (Case 16).—Left, prereduction view, showing exposure of the inferior one-third of the glenoid and the appearance of the humeral head in marked internal rotation. Right, postreduction view, showing restoration of normal glenohumeral relationship.

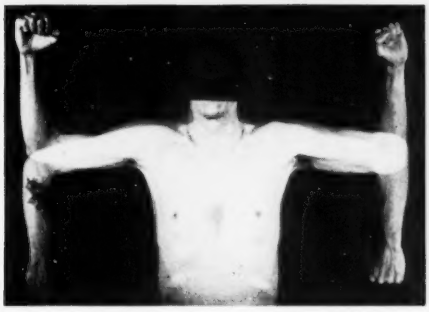


Fig. 14 (Case 16).—Posterior dislocation. Treated by closed reduction with immobilization in abduction and external rotation. View demonstrates full range of motion.

Fig. 16 (Case 1).—Posterior dislocation. Treated by closed reduction and immobilization. View demonstrating method of plaster immobilization in abduction and external rotation.

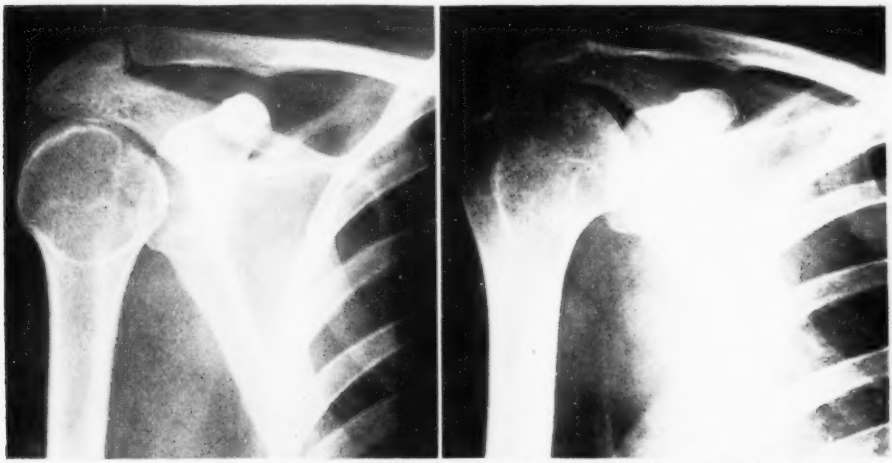
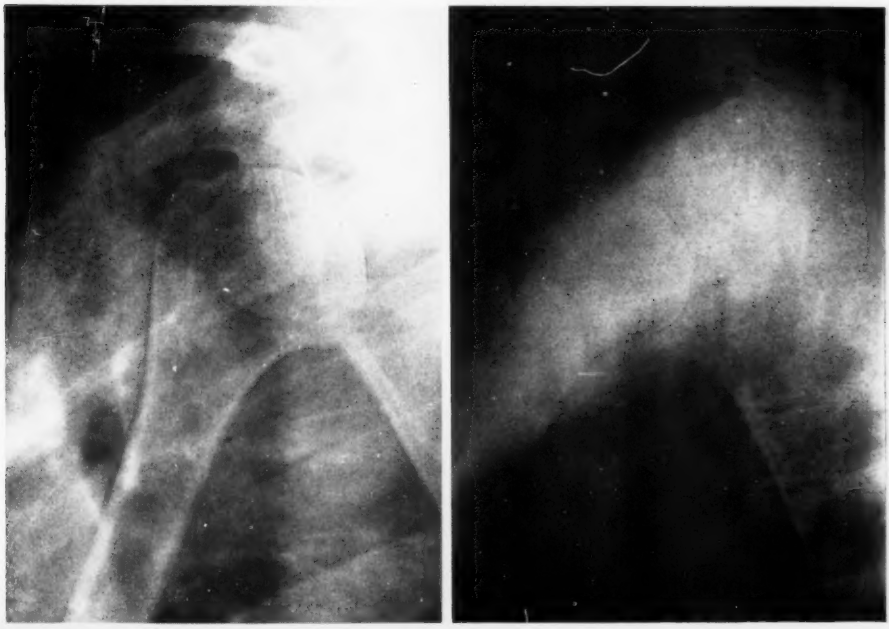


Fig. 15 (Case 1).—*A*, Left, prereduction anteroposterior film, showing the marked internal rotation of the shoulder with cystic appearance of head. *B*, Right, view after reduction.

Fig. 17 (Case 1).—Transthoracic views before and after reduction, showing interruption and restoration of scapulohumeral arch.



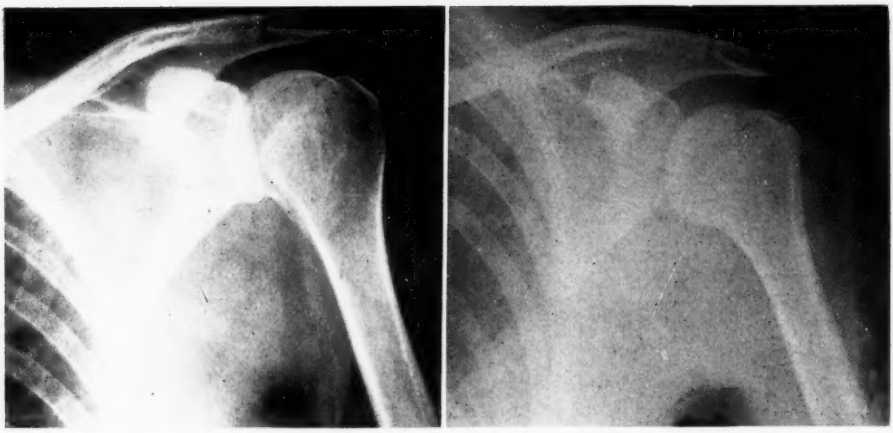
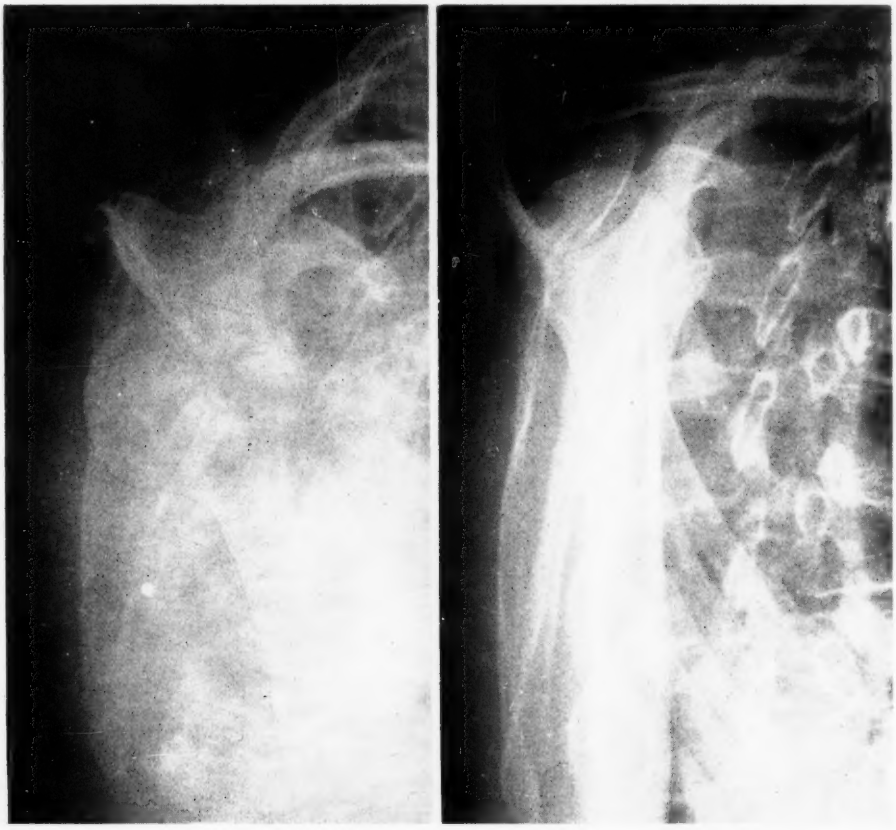


Fig. 18 (Case 2).—Anteroposterior views before and after reduction, demonstrating overlap of humeral head and glenoid labrum.

Fig. 19 (Case 2).—Oblique views before and after reduction, demonstrating relation of humeral head to glenoid labrum.



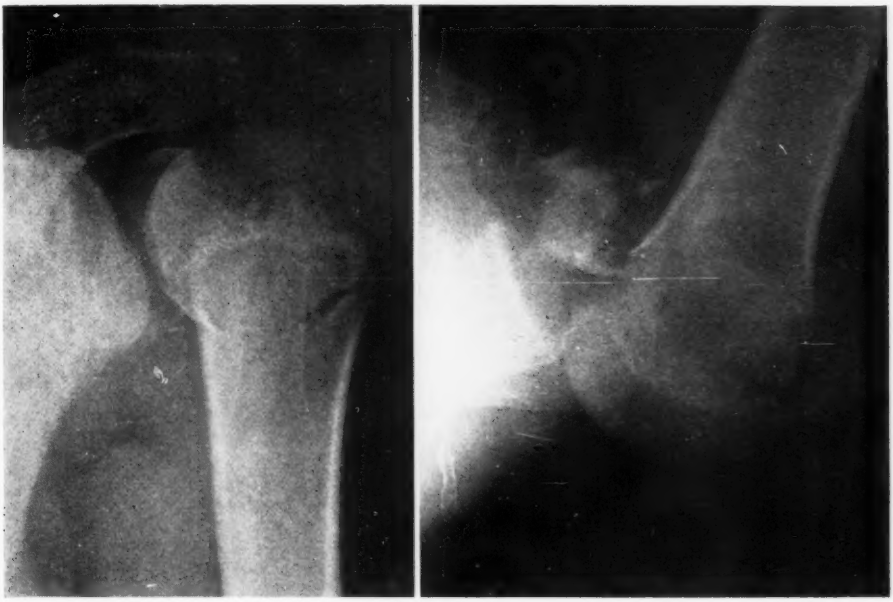


Fig. 20 (Case 13).—Left, cystic appearance of head. Fracture of surgical neck. Exposure of inferior one-third of glenoid. Right, axillary view; head dislocated posteriorly. Associated fracture of head with free fragment.

Fig. 21 (Case 13).—Postoperative open reduction demonstrating humeral head defect.

by the extensive soft-tissue and bony damage. The head is usually extracapsular, having been forced through a tear in the capsule, or the capsule may have been avulsed from the neck of the scapula. On occasion, the glenoid labrum is stripped away. In contrast to this, in the chronic recurrent types the head is usually found lying within a pouch of stretched capsule posteriorly beneath the rotator cuff.

The degree of bony injury to the humerus varies from a minor defect in the anterior aspect of the head where the humerus has struck against the glenoid rim (Case 13) to a markedly comminuted fracture of the head and neck. Frequently, one or both tuberosities have been avulsed. Occasionally, the head and neck are seen dislocated posteriorly as a free fragment. Neurovascular damage is rare because of the absence of important neurovascular structures posteriorly.

Closed reduction of posterior dislocation without extensive bony injury is not difficult. Under anesthesia gentle traction on the long

Diagnosis, Treatment, and Results in Seventeen Cases of Posterior Shoulder Dislocation

Case No.	Age, Race, Sex	Etiology	Clinical and X-Ray Diagnosis	Treatment	Functional Result
1	35 W F	Automobile accident	Arm held in adduction and internal rotation; humeral head prominent posteriorly; x-rays confirmed clinical diagnosis	Closed reduction, immobilization in long arm cast in abduction and external rotation with chest piece for 3 wk., then begun on periarthritic exercises	8 wk. later: estimated recovery of shoulder function 50%; 65° active abduction; 30° external rotation; progressively increasing return of range of motion; no further follow-up
2	59 W F	Secondary to electroshock therapy	Humeral head palpable posteriorly; x-ray revealed posterior dislocation with associated fracture through anatomical neck of humerus	Side-arm traction in abduction and external rotation for 10 days, followed by long arm cast in abduction and external rotation for 3 wk.	Full range of motion without pain
3	50 W F	Automobile accident	Initially diagnosed as fracture of surgical neck of humerus and greater tuberosity; unrecognized as posterior dislocation for 2 mo.	Hanging arm cast, periarthritic exercises	Fibrous ankylosis; abduction and elevation 115°; external rotation 30°; internal rotation 20°; full flexion; extension 40°; unable to get hand behind back or to comb hair, etc.
4	25 N M	Initial dislocation as result of fall from telephone pole; repeated dislocations since	Able to subluxate shoulder posteriorly with internal rotation and adduction	Shoulder harness; treated elsewhere by open reduction, fascia lata graft which failed	No functional disability with shoulder harness
5	23 W M	Automobile accident	Not seen initially; diagnosed elsewhere as posterior dislocation 5 wk. after injury	Open reduction, relocation with repair of massive rupture of rotator cuff; redislocated which necessitated open reduction again	Extensive soft-tissue ossification inferior margin of glenoid labrum; 45° of abduction; 10° internal and external rotation; flexion 50°; extension 30°; marked disability; poor result
6	27 W M	Direct blow over anterior aspect of shoulder during football game	Head protruded posteriorly; shoulder flattened anteriorly	Reduced on the field without anesthesia; no postreduction immobilization	Full range of motion
7	35 W M	In attempting to stop fall, reached out with arm in internal rotation and adduction; sustained posterior dislocation	Patient noted fulness of shoulder posteriorly	Reduced dislocation by rolling on ground, pressing forward with left hand on shoulder; history of 3 subsequent dislocations; first 2 reduced by friend with foot in axilla; last injury 4 yr. after original, reduced under anesthesia by physician	Pain with flexion and adduction of shoulder; adduction and internal rotation limited
8 and 9	61 W F	Grand mal seizure following administration of atropine in treatment for patient's mental illness	Initial diagnosis: bilateral comminuted fractures of head and neck of humerus; diagnosis of posterior dislocations made by x-ray 1 wk. after injury	Open reduction with screw fixation; postreduction immobilization in bilateral shoulder spica with shoulders immobilized in abduction and external rotation	6 yr. follow-up: full range of motion of left shoulder without pain; right shoulder lacks 30° of full elevation; abducts to 110°; lacks 20° full internal rotation; otherwise, normal range of motion without pain; no functional disability

10	55 W M	Fall from a scaffold onto shoulder	Initial diagnosis was one of comminuted fracture of head of humerus with posterior dislocation of humeral head	Side-arm traction with pin through olecranon; traction for 8 wk., then placed in airplane splint in abduction and external rotation	8 wk. after physiotherapy begun: active abduction 90°; flexion 110°; internal rotation 30°; external rotation 30° without pain
11	43 W M	Automobile accident	Incorrectly diagnosed as comminuted fracture of head of humerus	Hanging arm cast	No follow-up examination; patient failed to return
12	46 W M	Automobile accident	Initially diagnosed as fracture of greater tuberosity of humerus; treated with hanging arm cast; diagnosis of posterior dislocation made 3 wk. after injury; confirmed by x-ray	Open reduction and repair of capsule; Nicola tenodesis	Full, painless range of motion except for loss of 15° full elevation and last 15° of external rotation; no functional disability
13	22 W M	Automobile accident	Arm in adduction and internal rotation; clinical diagnosis on admission; x-rays revealed associated fracture of greater tuberosity of humerus	Closed reduction, immobilization in Velpeau dressing; instability with recurrence of dislocation; open reduction, repair of the capsule and rotator cuff; excision of tuberosity, which lay as free fragment, and Nicola tenodesis; postreduction immobilization in shoulder spica in abduction and neutral rotation	No follow-up; patient failed to return
14	39 W M	Secondary to electroshock therapy	Initial diagnosis: avulsion fracture of greater tuberosity of humerus; able to comfortably internally rotate shoulder and place hand on opposite shoulder; depression in anterior shoulder region; axillary view obtained and showed posterior dislocation	Closed reduction; immobilization in Velpeau dressing which was not tolerated by patient; (placed in sling and swathe; active exercises begun)	Range of motion 3 wk. after injury: full range of motion except for last 30° of abduction and last 15° of internal rotation; motion painless
15	46 W F	Secondary to electroshock therapy	Diagnosis suspected clinically, confirmed by x-ray on initial examination	Closed manipulative reduction; immobilized in Velpeau dressing; reduction lost, placed in traction in abduction and external rotation for 4 wk., after which patient was placed in airplane splint and physiotherapy begun	4 mo. follow-up; good range of motion in all directions; painless, except for slight limitation in external rotation
16	38 W M	Dislocation secondary to insulin shock therapy	Diagnosis made 2 wk. after injury; x-rays revealed simple posterior dislocation	Closed reduction and immobilization after reduction in airplane splint in abduction and external rotation; early active motion	On follow-up examination, 4 yr. after injury: full, painless range of motion
17	50 W M	Posteonvulsive, secondary to closed head injury	Diagnosis missed initially; suspected clinically 1 wk. after injury; confirmed by x-ray	Closed reduction and immobilization in Velpeau dressing with prompt recurrence of dislocation; treated with Kirschner wire traction through olecranon in abduction and external rotation for 4 wk.	Follow-up 2 mo. after injury: full, painless range of motion except for slight limitation of internal and external rotation

axis of the humerus with external rotation plus direct forward pressure upon the humeral head will usually relocate the head with ease. The problem is not one of achieving reduction but rather of maintaining it. It is our experience that reduction is usually unstable and easily lost, particularly with adduction and internal rotation. Open reduction has, in the past, been frequently necessary to achieve stability of reduction.

Until recently, there has been little mention in the literature of the stability of posterior dislocations once they are reduced. Most authors have immobilized the shoulder in a Velpeau dressing for a period of two to three weeks exactly as with anterior dislocation.

McLaughlin [7] feels that reduction is stable in acute cases, even in internal rotation and adduction. His program of after-care is one of temporary protection in a sling and swathe and early motion. Opposed to this view are Wilson and McKeever,[5] who note that reduction is usually unstable and that dislocation tends to recur. It is their feeling that the position of greatest stability is one of internal rotation of the humerus with the forearm bandaged behind the back. Because of the great discomfort of this position, they employ two transfixion wires through the acromium into the humeral head for a brief period until healing has occurred.

To illustrate, Case 1 was, typically, one in which we were confronted with the problem of maintaining reduction. The dislocation was easily reduced under intravenous meperidine (Demerol) but recurred immediately with motion in any direction. When immobilized in a Velpeau dressing, the reduction was very unstable. Open reduction was entertained, but a trial of immobilization was recommended in a long arm cast in 40 degrees of abduction and 65 degrees of external rotation. The dislocation proved to be very stable in this position. It is generally acknowledged that the Velpeau position of internal rotation and adduction is the proper method of immobilization, after reduction, of an acute anterior dislocation of the shoulder. It seemed logical that the position of optimum stability for a posterior dislocation was one of external rotation and abduction, and this has been borne out clinically in our group of cases. We now recommend that all acute posterior dislocations be immobilized in this manner for a period of three weeks, after which Codman's periarthritic exercises are begun.

Dislocations associated with extensive bony damage to the humeral head and neck present a more difficult problem. In our experience these are best treated initially for a period of two to three weeks in side-arm traction, with the shoulder in a position of abduction and external rotation, after which they are immobilized in a long arm cast, with a chest piece for stability, in external rotation and abduction for two weeks. Exercises are then begun. The significant fact to remember is that the position of greatest stability, after reduction, of posterior dislocation of the shoulder is one of abduction and external rotation.

Frequently, early open reduction is indicated, as in the case in which, following closed reduction and immobilization, the dislocation remains definitely unstable, or when there is marked displacement which is irreducible by closed means. The repair consists essentially of closure of the rent in the capsule and rotator cuff plus a Nicola tenodesis to lend stability. Open reduction is not without its hazards, however, as demonstrated by Case 5, who was operated upon elsewhere. After the first open reduction, dislocation recurred and open reduction was again advised. Subsequently, the patient developed extensive ossifying hematoma over the inferior glenoidal rim, sharply limiting his range of motion and causing him discomfort and considerable functional disability.

In our 17 cases (16 patients) employing the following criteria:

Normal	Full painless range of motion
Excellent	Painless; minimal limitation of motion
Good, early	Progressive painless range of motion; limited follow-up
Poor	Pain and functional disability

We obtained these results:

4—Treated by open reduction:
1 normal, 2 excellent, 1 no follow-up

6—In external rotation and abduction:
2 normal, 2 excellent, 2 good, early

1—Sling and swathe:
1 good, early

2—Operated on elsewhere:
2 poor—1 developed extensive soft tissue ossification and 1 recurrent posterior dislocation

2—No immobilization after reduction:
1 normal, 1 poor (developed recurrent posterior dislocation)

2—Remained undiagnosed until late:
1 refused further treatment; patient developed fibrous ankylosis; 1 no follow-up

SUMMARY AND CONCLUSIONS

At the University Hospital and its affiliated centers, our experiences with 17 cases of posterior dislocation of the shoulder are reviewed.

Early accurate diagnosis with proper treatment is essential. The possibility of this lesion being present must always be borne in mind in acute shoulder injuries. X-rays in two planes must be the rule in such injuries, including all apparent fractures of the head and neck of the humerus.

The position of greatest stability, after reduction, of acute posterior dislocation of the shoulder is one of external rotation and abduction.

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Multiple Arteriosclerotic Aneurysms of the Abdominal Aorta and Common Iliac Arteries

Report of a Case Successfully Treated by Homograft Replacement

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Since the memorable report of Estes,[7] in 1950, in which he followed 102 cases of untreated abdominal aortic aneurysm to their inevitable fatal termination, reporting one-third dead in one year and more than 80% dead in five years, the majority from rupture of the aneurysm, renewed hope has been given both the patient and clinician concerned with this disease. The literature during the past two or three years now abounds with the reports of successful resections of such aneurysms with replacement by homografts and in some cases by prosthesis. Dubost,[6] Gross, Hufnagel,[3] De Bakey,[4] Bahnson [1] and others furnish material that indicates not only that this type of procedure can be performed with a decreasing surgical mortality but also that longevity may be extended to approach the normal expectancy.

Reports of multiple aneurysms of the abdominal aorta and the common iliac vessels, however, appear to be extremely rare. In Bahnson's [1] review of 14 cases in which he made careful drawings of all his cases, only 1 gave visual indication of a secondary small aneurysm of the right iliac artery, unmentioned in his discussion. In De Bakey's [5] report of 49 cases treated surgically, no pictorial or descriptive mention of multiple aneurysms was observed. Undoubtedly, multiplicity is not as rare as these reports might lead one to believe; I alone have encountered two such cases within the past few months (Fig. 1). It is in the belief that such associated lesions will in the future be not infrequently encountered that the following case is presented. Certain other aspects of the case are unusual and add to the interest and value of the presentation.

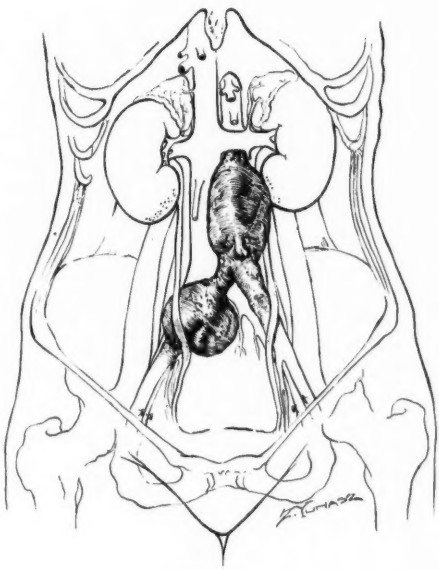

Figure 1.

REPORT OF A CASE

A white male laborer, aged 63, of English birth was admitted to the hospital on Feb. 22, 1955, with the complaint of pain of the right lower quadrant and right flank of two days' duration, associated with constipation, nausea, and vomiting during the previous 12 hours. Blood pressure on admission was 180 systolic, 100 diastolic. White blood cell count was 15,000, with a neutrophile value of 87%; hemoglobin level 13.4 gm.; red blood cell count 4,600,000. The chest configuration and ausculatory sounds indicated chronic bronchitis with emphysema. Abdominal findings revealed no

Submitted for publication Sept. 19, 1955.

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palpable masses, but tenderness and spasm in the right lower quadrant were present. There was no past history of similar attacks or of abdominal, back, or leg pain, or claudication.

A diagnosis of acute appendicitis was made, and the patient was taken to surgery on the day of admission. Through a McBurney type incision an innocuous-appearing appendix was seen, but the palpating finger of the surgeon discovered a globular, pulsating, tense mass about 6 cm. in diameter apparently arising from the bifurcation of the aorta at the site of origin of the right common iliac artery. There was no evidence of gross bleeding at this time, and, there being no graft immediately available, the abdomen was closed. The patient withstood this procedure well, and, although complaining of the preoperative pain of several days, he made an uncomplicated postoperative recovery. Studies during this period revealed x-ray evidence of abdominal aortic aneurysm measuring 12×5×5 cm. extending from L-2 to L-5, calcification involving both iliac vessels, moderately advanced pulmonary emphysema with enlargement, and engorgement of the pulmonary outflow tract.

After positive-pressure treatments and digitalization for a period of six weeks, the patient was returned to the hospital for definitive surgery. He continued to complain of some intermittent pain in the right flank but otherwise was asymptomatic. Blood pressure reading at this admission averaged 220/110. Femoral pulses were present, Grade III. Electrocardiographic studies revealed gross myocardial changes consistent with advanced arteriosclerotic heart disease. It was believed that this patient had received maximum benefit from medical treatment, and he was prepared for surgery.

On April 13, 1955, the patient was taken to surgery. A transperitoneal incision was made from the xiphoid to the symphysis on the medial aspect of the left rectus muscle. The posterior peritoneum was opened longitudinally from deep in the pelvis upward along the base of the mesentery to the ligament of Treitz, and the cecum, ascending colon, and terminal ileum were mobilized upward. The patient's abdominal viscera were eviscerated into a plastic bag on the upper abdominal surface. This gave excellent exposure of the aorta below the renal vessels and the iliac and epigastric vessels. Two aneurysms were found. One involved the abdominal aorta from a point 3 cm. below the left renal artery for a distance of about 8 cm., there to resume its normal size for 1 cm. Just below this point at the bifurcation and involving the bifurcation and the right common iliac artery, there was a second aneurysmal dilatation about the size of a hen's egg, which had dissected and partially ruptured posteriorly adjacent to the bifurcation of the vena cava. There was a marked reaction in this area, and the aneurysm was densely adherent to the distal vena cava and its bifurcation and common iliac veins. The entire aorta below the renals, including both aneurysms and the iliac and hypogastric arteries, was dissected out and a Satinsky clamp, together with an umbilical tape, placed above the aneurysm about the aorta just below the renal arteries, mobilizing the left renal vein. Tape and clamps were also placed about the common iliac arteries. Fifty cubic centimeters of dilute heparin was injected into the aorta with a needle, and the Satinsky clamp was closed just below the renals and clamps closed over the distal vessels. The aneurysm was resected from above downward without difficulty, except where it involved the common iliac vein posteriorly where the vein was opened widely and had to be ligated. The homograft, which had been prepared after the manner of Hufnagel was then tailored to fit the situation and sutured in place with continuous arterial 0000 nonabsorbable surgical (silk) sutures in the aorta and continuous 00000 black nonabsorbable surgical (silk) sutures in the iliac vessels. The right hypogastric vessel was not incorporated in the anastomosis, being ligated with 00 black silk. The resection and anastomosis required a period of two hours, the graft segment having been flushed out with dilute heparin solution just before closing the last, or right, suture line. The clamps were then opened from below upward. The graft withstood the arterial pressure well, with minimal temporary leakage only at one point in the anterior surface, which was easily controlled with one single mattress suture. Pulsations were excellent throughout the graft and in both iliac vessels, although the pulsation in the right femoral vessel showed some diminution below the point of a small arteriosclerotic plaque about 4 cm. below the anastomosis. This pulsation, however, was considered adequate, and the peritoneum was closed over the grafted area with continuous chromic catgut. The intestine returned to its normal position. A Penrose drain was inserted and brought out through a stab wound in the right lower quadrant. The wound was closed with interrupted mattress sutures of No. 30 stainless steel wire; silk was used in the skin. Sponge and needle counts were reported correct. The patient withstood the procedure well and left the table in good condition.

After the patient was returned to the room, it was observed that the circulation in the right thigh and leg was inadequate and no pulsation was palpable in the right femoral artery. After a period of 45 minutes' observation, this condition failed to improve so the patient was returned to surgery for exploration of the right femoral and terminal superficial iliac arteries.

A longitudinal incision was then made in the right groin. The right femoral artery was exposed. It was pulseless and contained no flowing blood. A

longitudinal incision was made in the right femoral artery from the profunda branch to the inguinal ligament. The vessel was opened and a recent clot removed. There was still no blood flow from above. The artery was explored with small catheters. The point of obstruction found 4 cm. above the inguinal ligament, where a plaque was palpable within the vessel. With a small Cannon wire loop dissector the embolic clot at this point was withdrawn from above downward together with a small piece of dissected intima. There was a rapid pulsating flow of blood obtained, and the artery was closed with a continuous suture of 00000 black silk. Pulsation now appeared to be adequate. The wound closed with interrupted 000 black silk. Patient left the table in good condition, although his blood pressure did at one time drop to 90/50 with a rapid loss of blood in the femoral artery.

The pathologist reported arteriosclerotic aneurysms of the lower abdominal aorta and right common iliac artery with partial rupture of the latter (Figs. 2*A* and 2*B*).

Figure 2*A*.

The postoperative course of this patient was complicated by a lower-nephron nephrosis which, however, cleared spontaneously on about the fifth day. Some discoloration of the right calf and paresthesia of the right leg persisted for several days. However, motor function was never disturbed, and the patient was ambulatory on the fifth postoperative day. Femoral pulsations were normal bilaterally upon discharge, on the 21st day. This patient has continued to be well and active to date. It is of interest to note that upon x-ray examination of the chest on April 29, 1955, two months after surgery, the following report was submitted: "The heart now appears smaller than at the time of the last examination (April 1, 1955). The prominence of the ascending aorta has diminished somewhat. The lung fields are normal."

SUMMARY

A case of multiple arteriosclerotic aneurysms of the abdominal aorta and the right common iliac arteries, successfully treated by homograft replacement has been presented. Certain unusual and interesting aspects of the case have been described. Such multiple lesions will undoubtedly be encountered by vascular surgeons in the future.

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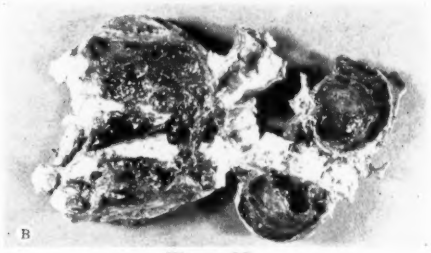

Figure 2*B*.

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Adrenal Cortical Hyperplasia Accompanying Cancer

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and
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The adrenal cortex has become a focus of interest in studies of human cancer since Huggins and co-workers [1] in the last 10 years demonstrated the therapeutic effects of surgical adrenalectomy. Recently, so-called "medical adrenalectomy" after cortisone administration also has been thought to influence favorably the courses of certain patients with metastatic cancer.[2]

No significant morphologic alterations of the adrenal have been observed accompanying the common types of cancer, although a variety of abnormal cortical secretion products has been identified, particularly by Dobriner and his associates.[3] The present analysis is part of a pathologic study of more than 1000 autopsied cancer patients, with particular attention to persons with multiple primary cancers. The findings concerning adrenal cortical hyperplasia demonstrate (1) the types of neoplasms more and less frequently associated, (2) the higher incidence of the adrenal cortical hyperplasia accompanying multiple primary cancers, and (3) the lower incidence in noncancer as compared with cancer autopsies.

Submitted for publication August 3, 1955.

Aided by grants C-1413 (C) and C-1754 (R), United States Public Health Service.

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MATERIAL AND METHODS

Clinical histories, gross autopsy protocols, and microscopic slides were examined from 1012 cancer cases provided from six hospitals in the Boston area. All available instances of multiple primary cancer [4] were sought, and 318 acceptable instances were included. Component cancer control cases were selected with the same sex, age within ± 10 years, and of a cancer site and histologic type corresponding to each neoplasm observed in a multiple cancer case. Six hundred ninety-four such cases with single cancers were examined. Among the cancer autopsy cases, 66.0% were men and 34.0% women. Three hundred ninety-three autopsies without cancer, of representative ages and comparable sex representations, were studied as noncancer controls.

Particular scrutiny was made for changes in endocrine glands and target organs. Certain findings concerning the pancreas,[5] pituitary, and other organs have been reported, and additional observations are to be published later.

A total of 72 cases of adrenal cortical hyperplasia was collected, 60 in the cancer groups. Gross adrenal weights were often not recorded or were considered unreliable. All 14 adrenal hyperplasia cases with accurate complete records among the 60 cancer autopsies just cited had aggregate adrenal weights exceeding the normal maximum of 10 to 12 gm. Six cases had total adrenal tissue weighing 15 to 20 gm.; three, 21 to 25 gm.; one, 26 to 30 gm.; two, 31 to 35 gm., and two more than 40 gm. Twelve others among this cancer group had adrenals described as thickened or enlarged, and the remaining hyperplastic glands were referred to grossly merely as negative for metastases. Hence, hyperplasia of adrenal cortex was defined as a thickening of the cortex, so that it measured 2.0 mm. or more from capsule to medulla. The measurements were made directly on the microscope stage, with a translucent millimeter rule. Care was taken to identify the three cortical zones, capsule, and medulla, so that oblique sections simulating hyperplastic thickening would be excluded. The definition of hyperplasia employed would exclude all but outspoken instances of adrenal cortical hyperplasia.[6] All cases observed were bilateral hyperplasias of the zona fasciculata,

with abundant cytoplasmic lipid present, as judged by fine vacuoles in paraffin sections. No cases of Cushing's or adrenogenital syndromes were recognized.

RESULTS

In the multiple cancer cases 24 cases of hyperplasia were found (7.5%); in the component single cancer group there were 36 cases (5.2%), and among the noncancer controls, 12 cases (3.1%). The probability of this occurring by accident is only 15 in 1000. Taken as a whole, cancer cases were accompanied by adrenal cortical hyperplasia in 5.9%, compared with 3.1% for noncancer controls.

TABLE 1.—*Analysis of Age, Sex, and Adrenal Cortical Hyperplasia Found in 1012 Neoplastic Autopsies*

	Women, 18 (30%)		Men, 42 (70%)	
60 Cases of Adrenal Cortical Hyperplasia				
Age Group	Number	% of Total	Number	% of Total
30-39	0	0	1	1.7
40-49	1	1.7	2	3.3
50-59	3	5.0	5	8.3
60-69	7	11.7	8	13.3
70-79	6	10.0	24	40.0
80-89	1	1.7	2	3.3
	Women, 324 (34.0%)		Men, 628 (65.9%)	
952 Cases Without Adrenal Cortical Hyperplasia				
20-29	4	0.4	3	0.3
30-39	4	0.4	2	0.2
40-49	24	2.5	25	2.6
50-59	82	8.6	102	10.7
60-69	111	11.7	204	21.4
70-79	84	8.8	222	23.3
80-89	15	1.6	67	7.0
90-99	0	0	3	0.3
Average age:	63.1 yr.		67.8 yr.	
Average age of total group: 65.4 yr.				

Table 1 also analyzes the ages and sexes of the 60 cancer cases accompanied by adrenal hyperplasia. The representation by sex and age was about the same as in the entire cancer series. The greatest frequencies occurred at 60 to 69 years, with 25% of all cases, and 70 to 79 years, with 50% of the total. The average age of these cases was 67.5 years, 66 for women and 68 for men, and 65.4, 63.1, and 67.8 years respectively for the comparable cancer groups without adrenal hyperplasia. Among the 952 cases without adrenal cortical hyperplasia, 33.1% were 60 to 69 years old, and 32.1% were 70 to 79 years of age (Table 1).

Body weights of the 60 cancer cases with adrenal hyperplasia indicated the patients to be emaciated in 20, of normal weight in 26, and obese in 14 instances. Two-thirds of the group thus were well nourished or overweight, and inanition accompanied adrenal hyperplasia in the remaining third.

The contingency of occurrence of adrenal cortical hyperplasia accompanying single cancers is shown in Table 2. For various sites urinary bladder cancers had the highest incidence, 23.5%; endometrium second highest, with 17.6%, and kidney third, with 9.5% adrenal cortical hyperplasia, but these subgroups were too small for detailed analysis. Respiratory tract cancers with adrenal

TABLE 2.—*Contingency Chart of Adrenal Cortical Hyperplasia in Single Cancer Cases*

	Female			Male			Combined Cases		
	Total Cases	Cases with ACH	Incidence, %	Total Cases	Cases with ACH	Incidence, %	No. Cases	Cases with ACH	Total Incidence, %
1 Bladder	2	1	50.0	15	3	20.0	17	4	23.5
2 Endometrium	17	3	17.6	..	..	....	17	3	17.6
3 Kidney	6	0	0	15	2	13.3	21	2	9.5
4 Respiratory	7	1	14.3	27	2	7.4	34	3	8.8
5 Prostate	..	..	....	107	6	5.6	107	6	5.6
6 Gastrointestinal	64	3	4.7	138	7	5.1	202	10	5.0
7 Skin	11	0	0	53	3	5.6	64	3	4.7
8 Breast	42	2	4.8	2	0	0	44	2	4.5
9 Cervix	24	1	4.1	..	..	....	24	1	4.1
10 Pancreas	10	0	0	9	0	0	19	0	0
11 Ovary	10	0	0	..	..	....	10	0	0
12 Ureter & Urethra	1	0	0	1	0	0	2	0	0
13 Testis	..	..	....	1	0	0	1	0	0
Totals	194	11	5.7	368	23	6.3	562	34	6.0

hyperplasia in 8.8%, prostate cancers with 5.6%, and gastrointestinal cancers with 5.0% were larger homogeneous groups with high incidences. Skin, breast, and cervix all had somewhat more than 4% of cases with adrenal cortical hyperplasia. Adrenal hyperplasia was not found with 19 pancreatic or 10 ovarian cancers.

Multiple as well as single primary cancer cases with adrenal hyperplasia are considered in Table 3. Urinary bladder, endometrium, respiratory tract, prostate, and kidney still had the highest incidences of adrenal hyperplasia accompanying cancer of these sites. Except for pancreas, cervix, and ovary as sites, incidences of adrenal hyperplasia were still about twice the figure observed in noncancer control material.

Single and multiple cancer groups are separately analyzed in Table 4. Adrenal cortical hyperplasia was observed in about one of every 6 multiple primary cancer cases involving respiratory tract, one of 8 in prostate, one of 11 in gastrointestinal tract, and one of 13 in breast. There was adrenal hyperplasia in four of eight men with both respiratory and prostatic cancers.

Adrenal cortical hyperplasia accompanied single urinary bladder, kidney, and endometrial neoplasms more frequently than when multiple cancers were found. The groups available for analysis were, however, too small to be significant. Collection of urogenital cancers in greater numbers would help determine whether there is regularly an associated alteration of the adrenal cortex unlike that found accompanying other cancers.

TABLE 4.—*Incidences of Adrenal Cortical Hyperplasia with Single and Multiple Cancers by Sites*

Sites	Single Cancers	Multiple Cancers
Respiratory	3/34 (8.8%)	5/31 (16.1%)
Prostate	6/107 (5.6%)	14/110 (12.7%)
Bladder	4/17 (23.5%)	2/17 (11.7%)
Pancreas	0/19 (0%)	2/19 (10.5%)
Gastrointestinal	10/202 (5.0%)	15/160 (9.4%)
Breast	2/44 (4.5%)	3/39 (7.7%)
Endometrium	3/17 (17.6%)	1/14 (7.1%)
Kidney	2/21 (9.5%)	1/19 (5.2%)
Cervix	1/24 (4.1%)	1/24 (4.1%)
Ovary	0/10 (0%)	0/10 (0%)

COMMENT

Despite the collection of more than 1000 pathologically proved cases of cancer, the various individual types of neoplasm found were numerically insufficient for any valid statistical conclusions concerning subgroups. The observations made are considered chiefly suggestive and worthy of trial by others in attempts to establish or refute their validity.

Adrenal cortex hyperplasia did not appear to show any age or sex distribution strikingly different from the entire cancer case material collected. The increased frequency with age was not of necessity related to cancer. Old experimental animals, such as mice, have shown adrenal cortical hyperplasia development without evident clear-cut connection to neoplastic tendencies.[7]

It was quite unexpected to find in both single and multiple primary cancer cases that

TABLE 3.—*Analysis of Ten Groups from Total Cancer Autopsies (1012)*

Group	Total Cases	Per Cent of All Cancer	Cases of Multiple Cancers		Cases with Adrenal Cortical Hyperplasia	
			No.	% of Group	No.	% of Group
1 Bladder	34	3.4	17	50.0	6	17.6
2 Endometrium	31	3.1	14	45.1	4	12.9
3 Respiratory	65	6.4	31	49.6	8	12.3
4 Prostate	217	21.4	110	50.7	20	9.2
5 Kidneys	41	4.1	20	48.7	3	7.3
6 Gastrointestinal	362	35.8	160	44.2	23	6.4
7 Breast	83	8.2	39	46.9	5	6.0
8 Pancreas	38	3.7	19	50.0	2	5.2
9 Cervix	48	4.7	24	50.0	2	4.2
10 Ovary	20	1.9	10	50.0	0	0

respiratory-tract, prostate, and gastrointestinal sites were the largest homogeneous neoplastic groups with the highest incidences of accompanying adrenal cortical hyperplasia. That the frequencies in each instance followed in the same order likewise appeared notable. In cancers of bladder, kidney, and endometrium the frequency of adrenal cortical hyperplasia was even higher, but the small number of cases and selection factors hindered interpretation of the significance.

Persons with multiple primary cancers had adrenal hyperplasia on the order of twice as frequently as those with single cancers of similar sites. This was evident and statistically significant to a high degree for respiratory tract, prostatic, and gastrointestinal neoplasms, but not for the small urogenital subgroup. Adrenal participation in a complex endocrine imbalance in many persons harboring multiple separate malignant tumors is thus suggested.[8] From analysis of autopsy material it is difficult to establish whether the adrenal enlargement was a forerunner or an accompaniment of an established cancer.

Pertinent experimental procedures [10] leading to adrenal cortical hyperplasia in animals are, in particular, the following: 1. Estrogen effects. Study of ovaries from human cases of lung and stomach cancer makes it evident that stromal hyperplasia and inferred continuous ovarian estrogen secretion characterize a large majority of women with these two types of cancer.[11] Evidence recently collected also favors long-continued estrogenic stimuli in the background of about two-thirds of men with prostatic cancers. 2. Hypermetabolic and protein catabolic states. These are sometimes lumped under the term "chronic stress" and might theoretically be implicated as cocarcinogenic influences, but there does not appear to be any reliable evidence that "stress" is a characteristic part of the background of human cancers.

In experimental situations starvation and inanition associated with a loss of tissue protein are sometimes accompanied by an enlargement of the adrenal glands. The cancer cases with adrenal hyperplasia collected were in the majority not cachectic, however, and weight loss had not been great in two-thirds of the group. Whereas the presence of cancer alone was not thought sufficient to explain the adrenal cortical enlargements observed, inanition did not appear to account for its frequency.

Adrenal cortical hyperplasia could be induced secondarily through the metabolic and endocrinologic activities of established cancers. Evidence for such secondary hyperfunctions includes the uniform finding of increased hypertrophic amphophile cells in the anterior pituitary lobes of patients dying of a variety of types of cancer.* Mellgren [12] first recognized hypertrophic amphophile cells as connoting adrenal cortical hyperfunction, either nonspecific or of clinically specific types, like Cushing's syndrome. While more data need to be accumulated, at present it would appear that a pituitary-adrenocortical hyperfunction, involving pituitary and adrenal hormones not yet isolated, is the rule in persons dying with malignant tumors. Corticotropin (ACTH) and cortisone do not seem to participate. Adrenal stimulation by pituitary amphophile and hypertrophic amphophile cells results in an adrenal cortical hyperplasia in animals and probably in some patients. Secondary stimulation following cancer growth may likely explain the hyperplastic adrenals accompanying the cancers of skin and cervix, as well as some breast cancers.

Whether adrenal cortical hyperplasia precedes or follows the establishment of a cancer, its structure and the abundant lipid suggest functional activities. The relative frequency with which adrenal enlargement accompanied respiratory tract, prostatic, and gastrointestinal cancers, particularly those of the stomach, would favor the employment of surgical or "medical" adrenalectomy procedures on late inoperable cases of these types. The rather heterogeneous urinary tract cancers might provide another favor-

* References 9 and 12.

able group for adrenalectomy. Persons with multiple primary cancers of these sites would also be theoretically more likely to benefit from ablation or inhibition of the adrenal fasciculate zone functions. A present-day regimen developed to manage prostatic carcinoma involves the successive use of (1) surgical ablation of the primary site and orchidectomy, (2) cortisone, (3) adrenalectomy, and (4) hypophysectomy.[14]

It is reiterated that a retrospective study of this type has recognized limitations of scope and significance. Differences in the frequency of adrenal cortical hyperplasia accompanying certain cancers or combinations of cancers, however, warrant attention because of the distinguishable host reactions to different forms of cancer.

SUMMARY

Adrenal cortical hyperplasia was found in 72 of 1405 autopsied cases reviewed pathologically, including 60 cases among 1012 cancer autopsies. Adrenal cortical hyperplasia accompanied 7.5% of the instances of multiple primary cancer, 5.2% of single-cancer cases, and 3.1% of 393 noncancer controls. Relatively high incidences of hyperplasia were observed with cancers of the respiratory tract, prostate, and gastrointestinal tract and in urinary tract neoplasms. Whether adrenal cortical hyperplasia developed before or after the establishment of cancer growth is discussed in reference to the mechanism of adrenal stimulation. Therapeutic adrenalectomy appears worthy of trial, particularly with inoperable cancers of the respiratory and gastrointestinal tracts.

The following pathologists provided material for this study: Dr. A. T. Hertig, Free Hospital for Women; Drs. S. P. Hicks and G. L. Dammin, Peter Bent Brigham Hospital; Dr. P. M. LeCompte, Faulkner Hospital; Dr. W. A. Meissner, New England Deaconess Hospital, and Dr. L. Reiner, Beth Israel Hospital, Boston. Drs. A. T. Hertig, Hugo Muench, and Shields Warren made suggestions and reviewed the manuscript.

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Carcinoma of the Head of the Pancreas, Long-Term Survival

Report of a Case

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The reported cases of patients surviving five years after radical pancreaticoduodenectomy for carcinoma of the head of the pancreas are rare.* Certainly there are some patients who have survived for this period or longer whose cases have not yet been published, and reports of these cases might lend stimulus to radical operations for this disease. The merit of reporting these cases has been noted by Orr.[5] The following previously unpublished report concerns a patient with carcinoma of the head of the pancreas and involvement of lymph nodes who has remained healthy throughout an eight-year period.

REPORT OF A CASE

A 59-year-old white retired rancher registered at the Mayo Clinic complaining of increased stomach trouble, loss of weight, and jaundice. Six years prior to his admission indigestion developed in the form of midepigastric distress occurring two to three hours after meals; ingestion of food gave relief. The clinical impression was "stomach ulcers," but his home physician was unable to obtain confirmation roentgenographically. The patient improved on dietotherapy.

One year prior to admission the patient noted general weakness and anorexia, which forced retirement, and four months prior to admission he noted shortness of breath and wheezing with exertion. For two months prior to admission he had felt ill generally. Weakness and anorexia increased, and he began to lose weight. A tonic was prescribed by his home physician because of the negative results of examination. One month prior to registration at the clinic his gastric symptoms changed: the midepigastric pain after meals of any type was now unrelieved by food. Anorexia and fatigue became severer than ever before. One week prior to admission jaundice developed; at times his urine was dark and stools were light. The patient occasionally vomited partially digested food. Total loss of weight at the time of registration was 30 lb.

Examination revealed an emaciated jaundiced man weighing 106 lb. Moderate emphysema was present, and a few crackling rales were heard at the right base of the thorax. Distention of the gall bladder was both visible and palpable through the thin abdominal wall. No other abdominal masses were found. Tarry stool was noted on the rectal examining finger. He was hospitalized for complete examination, which, because of complaints, was directed mainly toward the gastrointestinal tract.

Gastric aspirations during his hospitalization showed evening retention of 700 to 1200 cc. Laboratory examinations disclosed the presence of bile in the urine. The concentration of bilirubin per 100 cc. of serum was 7.76 mg. direct-reacting and 0.4 mg. indirect-reacting. The numbers of leucocytes and erythrocytes per cubic millimeter of blood were 6700 and 4,750,000, respectively; the value for hemoglobin was 13.1 gm. per 100 cc. of blood. The erythrocyte sedimentation rate was 53 mm. in the first hour (Westergren method). The value for urea was 74 mg. per 100 cc. of blood but descended to 28 mg. on hydration. The value for chlorides was 561 mg., and the carbon-dioxide-combining power of plasma was 71.1 vol.%. Roentgenographic study revealed a duodenal ulcer with a small crater. The junction of the first and second portions of the duodenum was partially obstructed, and the second portion of the duodenum was displaced to the left.

Accepted for publication Aug. 4, 1955.

Section of Surgery (Dr. Pratt); Assistant to the Staff (Dr. Welch), Mayo Clinic and Mayo Foundation. The Mayo Foundation is a part of the Graduate School of the University of Minnesota.

* References 1 to 6.

On July 3, 1947, exploration was carried out by one of us (Pratt) through a primary upper midline incision. A hard mass 2 cm. in diameter was located between the first and second portions of the duodenum; it extended into the pancreas and immediately on top of the common duct. The common duct was ¾ in. in diameter, and the gall bladder was distended. Stones could not be palpated. Other viscera, including the body of the pancreas, felt normal. The duodenum was incised, and a specimen was removed from the bed of a benign-appearing ulcer for biopsy. Results of biopsy were reported as equivocal, whereupon portions of the stomach and rim of the ulcer were sent as specimens. The diagnosis on this basis was carcinoma. A Whipple operation was then carried out; a portion of the common duct, approximately 65% of the distal portion of the stomach, the entire duodenum, and the head and uncinate process of the pancreas were removed. A segment of jejunum was brought through the transverse mesocolon, and an end-to-end pancreatojejunostomy was done with two rows of interrupted nonabsorbable surgical (silk) sutures. Pancreatic juice was observed to be flowing during the anastomosis. An end-to-side choledochojejunostomy was carried out 1 in. distal to the pancreatic anastomosis, made with two rows of interrupted silk sutures, and the jejunum was anchored about the common duct to relieve any tension. An anterior Polya-type gastrojejunostomy and a cholecystostomy over a dressed tube completed the reconstruction.

The pathologic report concerned 15 cm. of stomach, 17 cm. of duodenum and proximal jejunum, head of pancreas, and terminal 3 cm. of common duct. The portion of stomach weighed 145 gm. The head of the pancreas was the location of a Grade 2 scirrhous adenocarcinoma which measured 2.5 by 2 by 2 cm., with secondary ulceration of the duodenum in the region of the papilla. The growth obstructed the common duct, which was secondarily dilated. It also had spread along the perineural lymphatics with involvement of one peripancreatic node. A subacute and chronic duodenal ulcer, 2 by 1 cm., was situated in the first portion of the duodenum.

Postoperatively, persistent drainage of bile and continued loss of weight slowed the patient's immediate convalescence. Nasogastric suction was used for two days, with the recovery of only small amounts of gastric juice. The nasal tube was removed on the third day, and the patient was maintained by intravenously administered fluids until a progressive type of diet suitable to his need, created by the gastric operation which he had undergone, was satisfactorily commenced on the eighth postoperative day. He lost weight despite good intake of food until the 20th postoperative day. Administration of two pancreatin capsules three times daily was then started, and his weight began increasing immediately. He was dismissed to go home on the 27th postoperative day and instructed to take pancreatin, as noted, supplemented by two multivitamin capsules daily.

Subsequently, although the patient is in virtual retirement, he pursues his hobbies of hunting, fishing, and carpentry and is able to eat any food except eggs. He continued to take pancreatin for only four months after operation, but multivitamins have been used regularly. Occasional upsets presumed to be "dumping" have been controlled by eating five small meals daily. His weight has remained between 100 and 115 lb., and his general health is good. He has not had a recurrence of jaundice.

SUMMARY

A case of carcinoma of the head of the pancreas with one node involved is presented. The patient underwent radical pancreaticoduodenectomy. At the time of this report, eight years subsequent to his operation, no evidence of recurrence is apparent.

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Ventricular Fibrillation in the Hypothermic State

III. The Management of Coronary Air Embolism and Ventricular Fibrillation

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The present study was undertaken in order to investigate two potential complications of open cardiac surgery in the hypothermic state—coronary air embolism and ventricular fibrillation. The latter is difficult to manage under any circumstances and especially under hypothermic conditions. It constitutes the single greatest hazard of open cardiac surgery during hypothermia. In moderately cooled, normal, control dogs ventricular fibrillation occurs regularly when venous inflow into the heart is shut off and a right ventriculotomy is performed.[1] Air embolism to the coronary arteries constitutes a serious threat whenever an open left cardiotomy is performed or a right ventriculotomy is done in the presence of a ventricular septal defect. It is usually followed by ventricular fibrillation, especially during hypothermia.

MATERIALS AND METHODS

Healthy mongrel dogs were used. Anesthesia was induced by the intravenous administration of minimal amounts of thiopental sodium. Tracheal intubation was then carried out, and hyperventilation with oxygen was maintained for the remainder of the experiment by means of an intermittent positive-pressure apparatus. The lungs were inflated fully from 35 to 45 times a minute. Each animal was cooled to a rectal temperature of 30 C by immersion in a bath of ice and water. The operations were carried out under aseptic conditions. The right thorax was entered through the fourth intercostal space. The azygos vein was divided between ligatures. The two venae cavae were freed. The pericardium was opened widely, and the aorta was dissected free and a tape was placed about it. The venae cavae were occluded, and 30 seconds later the aorta was clamped distal to the origin of the coronary arteries with a noncrushing instrument. One minute afterward from 3.5 to 5 cc. of air, depending upon the size of the animal, was injected into the left ventricle by means of a syringe and a 25-gauge needle. After a few seconds air was easily discernible in large amounts in the coronary arteries, and the previously pink heart rapidly became cyanotic. In each animal a weak ventricular fibrillation followed. Fibrillation was allowed to continue for from three to five minutes, at the end of which time the fibrillation was ordinarily so weak that the vermiform movements were barely visible. The vena caval clamps were then released and cardiac massage was begun and continued vigorously. With this maneuver the major portion of the air in the coronary arteries was forced from these vessels in a period of from two to three minutes. The aortic clamp was removed, the animal was placed in Trendelenberg position, and the cardiac massage was continued. Often a few bubbles of air were still visible in the coronary arteries and there was patchy cyanosis limited to the areas about the obstructed coronary arteries. These air bubbles usually disappeared with massage, and the heart became well colored. When ventricular fibrillation persisted, electric shock was applied. If air bubbles continued to block one or more small coronary arteries, the terminal portion of each blocked artery was incised with a scalpel and the air was expressed by digital milking of the artery. The heart then became pink, and the contractions, stronger.

In half of the 20 dogs subjected to this procedure the sinoauricular node was blocked by injection of

Submitted for publication June 8, 1955.

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Aided by grants from the James Whitcomb Riley Memorial Association, the Indiana Heart Foundation, and by a contract between the Office of Naval Research, the United States Navy, and Indiana University.

the atrial wall with 1% procaine, either before or shortly after onset of ventricular fibrillation. In the other half no sinoauricular node blockade was carried out, except in one animal in which the node was paralyzed with procaine after ventricular fibrillation had recurred three times.

In eight other animals, after cooling each in the same manner and injecting air into the left ventricle, the right ventricle was opened widely and two nonabsorbable surgical (silk) sutures were placed in the ventricular septum and tied. The ventricle was then closed. By this time ventricular fibrillation had ordinarily been present for from five to six minutes. The vena caval clamps were released; massage was instituted, and, if necessary, terminal branches of coronary arteries were incised in order to permit milking out of any residual air. In half of these animals the sinoauricular node was blocked once ventricular fibrillation had occurred. In the other half the sinoauricular node was not blocked except in one animal in which this procedure was carried out after ventricular fibrillation had recurred nine times.

After completion of each experiment the animal was rewarmed and observed until spontaneous respirations had been resumed and heart action was good. Some of the animals were then killed. Others were killed several days later.

Efforts at defibrillation were made by the application of 170 volts of electric current for 1/10 of a second. Three such shocks were administered in rapid succession. If such electric shock was unsuccessful in restoring normal rhythm, massage was begun again, sometimes with aortic cross clamping. If electric shock was unsuccessful and the ventricular fibrillation was weak, from 2 to 3 cc. of 1 to 10,000 epinephrine solution was injected into the right ventricle, after which massage was carried out vigorously.

Occasionally, after restoration to a normal rhythm, the contractions of the heart were weak. Under such circumstances from 0.5 to 1 cc. of the epinephrine solution was administered into the right ventricle.

The temperature of all animals was from 25 to 27 C at the time of induction of fibrillation and air embolism.

Electrocardiographic tracings were made periodically during each experiment.

RESULTS

After the injection of air into the left ventricle, gross coronary air embolism was immediately evident and the previously well-colored heart became diffusely cyanotic. Shortly thereafter, ventricular fibrillation ensued. This was usually weak in character. With vigorous cardiac massage and aortic cross clamping, the air completely disappeared from the coronary arteries in some instances, with return of excellent color to the myocardium. In some, however, a few branches of the coronaries remained blocked

TABLE 1.—*Experiences with Treatment of Coronary Air Embolism and Ventricular Fibrillation in the Hypothermic Dog by Sinoauricular Node Blockade, Cardiac Massage, Intracardiac Epinephrine, and Electric Shock*

No. of Dog	Temperature of Dog, C	Volume of Air Injected, Cc.	Interval Between Injection of Air and Onset of Fibrillation	Time of Sinoauricular Node Blockade with Reference to Onset of Fibrillation	Duration of Fibrillation Before Institution of Massage, Min.	Period of Massage Necessary for Cleaning Coronaries of Air, Min.	Total Duration of Massage and Fibrillation, Min.	Means Used for Conversion
1	26.5	5	5.5 min.	Before	3	1.5	6	Massage
2	26	5	5 min.	Before	2	2.5	15	Massage, epinephrine, shock
3	26	5	4 min.	Before	2.5	2.5	15	Massage, epinephrine, shock
4	26.5	4.5	.....	Before expected onset	..	2	..	No fibrillation
5	26	4	2 min.	After	3	2	6	Massage, shock
6	26.5	4	3.5 min.	After	3	7	10	Massage, epinephrine, shock, section coronary branch
7	27	4	3 min.	After	3	3	7	Massage, epinephrine, shock, section coronary branch
8	26	4	3.5 min.	After	3	6	9	Massage, shock
9	25.5	3.5	10 sec.	After	4	2	8	Massage, shock
10	26	4	5 sec.	After	4	12	19	Massage, shock, section, coronary branch

TABLE 2.—*Experiences with Treatment of Coronary Air Embolism and Ventricular Fibrillation in the Hypothermic Dog by Cardiac Massage, Intracardiac Epinephrine, and Electric Shock*

No. of Dog	Temperature of Dog, C	Volume of Air Injected, Cc.	Interval Between Injection of Air and Onset of Fibrillation	Duration of Fibrillation Before Institution of Massage, Min.	Period of Massage Necessary for Cleaning Coronaries of Air, Min.	Total Duration of Massage and Fibrillation, Min.	Means Used for Conversion
17	26.5	4	1.5 min.	5	2	17	Massage, shock
18	26.5	4.5	3	4	2	25	Massage, shock
19	27	4	45 sec.	4	1	6	Massage, shock
20	25.6	4	5 sec.	4	3	8	Massage, shock, epinephrine
21	26	4	1.5 min.	4	3	40	Massage, epinephrine, shock
22	26	5	45 sec.	5	3	8	Massage, shock
27	25	4	1.5 min.	4	2	6 Fibrillated twice	Massage, shock
30	26	4	2 min.	4	3	10 Fibrillated 4 times	Massage, epinephrine, sinoauricular block, shock
33	26	4	15 sec.	7	2	5	Massage, shock, epinephrine
34	26	4.5	15 sec.	6.5	2	5 Fibrillated 4 times	Massage, epinephrine, shock

TABLE 3.—*Experiences with Treatment of Coronary Air Embolism and Ventricular Fibrillation in Hypothermic Dogs Subjected to Right Ventriculotomy and Placement of Sutures in Ventricular Septum by Sinoauricular Node Blockade, Cardiac Massage, Intracardiac Epinephrine, and Electric Shock*

No. of Dog	Temperature of Dog, C	Volume of Air Injected, Cc.	Interval Between Injection of Air and Onset of Fibrillation	Time of Sinoauricular Node Blockade with Reference to Onset of Fibrillation	Duration of Fibrillation Before Institution of Massage, Min.	Period of Massage Necessary for Cleaning Coronaries of Air, Min.	Total Duration of Massage and Fibrillation, Min.	Means Used for Conversion
28	26	4	3 min.	After	4	3	13	Massage, epinephrine
29	27	4.5	2.5 min.	After	4	3	10	Massage, epinephrine, shock
31	26.5	4	1 min.	After	8	1	3	Massage, shock
32	26	4	2.5 min.	After	6.5	2	4	Massage, shock, epinephrine

TABLE 4.—*Experiences with Treatment of Coronary Air Embolism and Ventricular Fibrillation in Hypothermic Dogs Subjected to Right Ventriculotomy and Placement of Sutures in Ventricular Septum by Cardiac Massage, Intracardiac Epinephrine, and Electric Shock*

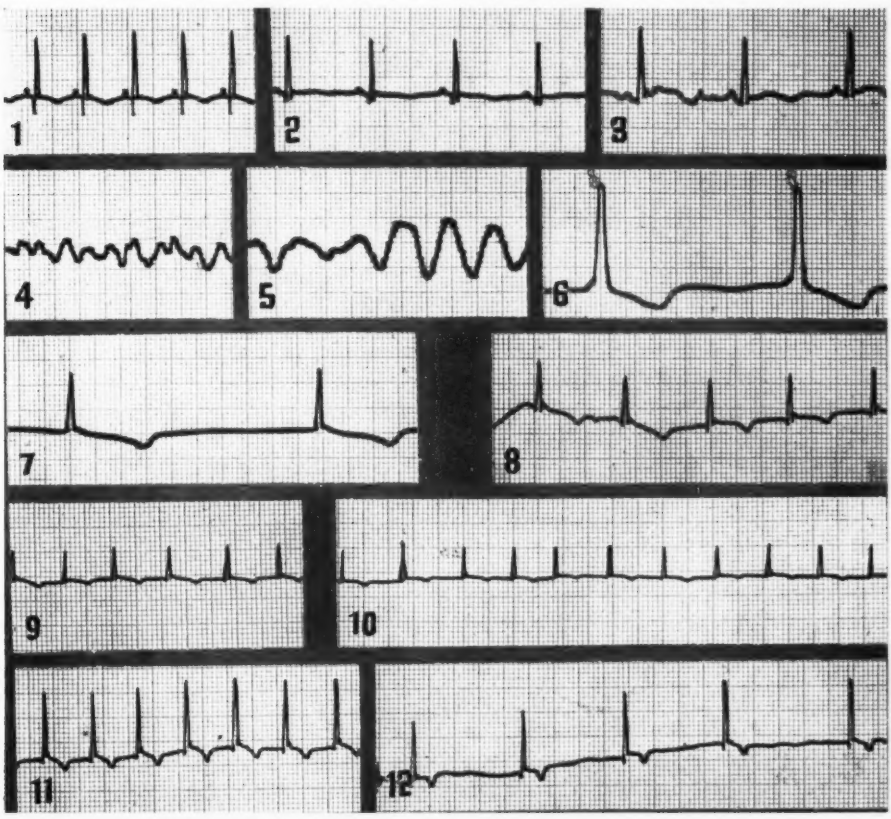
No. of Dog	Temperature of Dog, C	Volume of Air Injected, Cc.	Interval Between Injection of Air and Onset of Fibrillation	Duration of Fibrillation Before Institution of Massage, Min.	Period of Massage Necessary for Cleaning Coronaries of Air, Min.	Total Duration of Massage and Fibrillation, Min.	Means Used for Conversion
23	26	5	Immediately	8	2	12	Massage, section coronary branch, shock, epinephrine
24	27	4.5	30 sec.	7	1	5	Massage, shock
25	26	4	4 min.	4	3	10 fibrillated 3 times	Massage, epinephrine, shock
26	25.5	4	10 sec.	2	2	80 fibrillated 10 times	Massage, epinephrine, shock, section coronary branch, sinoauricular block

by bubbles of air and the adjacent myocardium remained cyanotic. When these plugged terminal branches of the coronary arteries were incised with a scalpel and the air was milked from them, the surrounding myocardium assumed a normal pink color. After the injection of dilute epinephrine solution into the right ventricle the weak ventricular fibrillation became stronger and the tonus of the heart muscle became good.

In 4 of the 10 animals comprising the first group the sinoauricular node was blocked prior to the onset of ventricular fibrillation (Table 1). Ventricular fibrillation did not occur in one. Normal rhythm was restored by cardiac massage alone in one of the three animals in which fibrillation developed. In the others normal rhythm was restored after cardiac massage, the intracardiac administration of epinephrine, and electric shock. In 6 of the 10 animals the sinoauricular node was blocked after the onset of fibrillation. Normal rhythm was restored in four with cardiac massage and electric shock alone. In the remaining two epinephrine solution was used as well.

Ventricular fibrillation occurred in all of the second group of 10 animals, identical with the first except for omission of sinoauricular node blockade (Table 2). In five a normal rhythm was restored by cardiac massage and electric shock. In one of the five epinephrine

Electrocardiographic tracings (Lead II) in Dog 8. (*1*), at rectal temperature 37.5 C; (*2*), at 31 C; (*3*), at 27 C; (*4*), after onset of ventricular fibrillation; (*5*), after institution of cardiac massage; (*6*), after defibrillation; (*7*), following closure of chest incision; (*8*), at 29.5 C; (*9*), at 33 C; (*10*), at 34.5 C; (*11*), at 36 C; (*12*), two days later.



was subsequently administered because of weak ventricular contractions. In the remaining five cardiac massage, intracardiac, epinephrine, and electric shock were utilized in restoring normal rhythm. Ventricular fibrillation recurred and was terminated four times in one of these animals.

In a third group of animals right ventriculotomy and placement of sutures in the ventricular septum was carried out after the induction of coronary air embolism (Table 3). All developed ventricular fibrillation. In one a normal rhythm was restored with massage and electric shock; in the second, after cardiac massage and the administration of epinephrine, and in the other two, after massage, the use of epinephrine, and electric shock.

In the fourth group, identical with the third except for absence of sinoauricular node blockade, two animals responded to massage and electric shock (Table 4). One of them subsequently required intracardiac epinephrine because of weak contractions of the heart. One of the animals developed ventricular fibrillation and underwent restoration to a normal rhythm with massage, intracardiac epinephrine, and electric shock, but fibrillation recurred two additional times before it finally disappeared. In the fourth animal ventricular fibrillation recurred 10 times and did not disappear permanently until the sinoauricular node was blocked with procaine prior to the last conversion with electric shock.

In all four groups of animals a normal rhythm and good cardiac contractions were restored (Figure). Each animal was rewarmed and regained effective spontaneous respiration. In each group the pupils which became dilated during the course of the experiment became smaller with the institution of cardiac massage and by the completion of the experiment were normal and reactive. Those animals which were not killed at the completion of the experiment seemed quite normal.

COMMENT

Coronary air embolism and ventricular fibrillation constitute alarming complications of open cardiac surgery, especially under hypothermic conditions. It is evident from other studies that coronary air embolism can be managed effectively only by some method which clears the coronary arteries of all bubbles of air. Geoghegan and Lam [2] found that it was possible to resuscitate 80% of normothermic dogs with coronary air embolism by vigorous cardiac massage during cross clamping of the descending aorta. Clowes * mentioned experiments in which air was driven backward out of the coronary arteries by the injection of saline into the coronary sinus. This method would seem to have no practical application. The problem of coronary air embolism is obviously more grave in the hypothermic state, since ventricular fibrillation itself is much more difficult to deal with under hypothermic circumstances than under normothermic conditions. In our study vigorous cardiac massage with cross clamping of the ascending aorta often resulted in complete clearing from the coronary arteries of the entrapped air and restitution of excellent color of the myocardium. In some instances, however, these measures failed to eliminate the air bubbles completely, which remained trapped in one or more of the terminal branches. As long as these minute air blocks existed, contiguous areas of the myocardium remained cyanotic and resuscitation was impossible. It was found that transection of the involved terminal coronary branches permitted one to milk the air out of these vessels, with restoration of good circulation to the myocardium. After resuscitation these minute bleeding points were taken care of by transfixion ligatures.

Ventricular fibrillation induced in the normal dog's heart at normal body temperature can be dealt with remarkably easily. In contrast, most investigators have had extraordinary difficulty in bringing about cessation of ventricular fibrillation in hypothermic animals and conversion to a normal rhythm. Swan and his colleagues [3] were unable to bring about such conversion with electric shock. They had considerable success with

* In discussion of Geoghegan and Lam.[2]

potassium chloride perfusion of the coronary arteries. We have had poor luck with this measure. Kirby and his associates [4] have pointed out the fact that voltages higher than 110 volts, commonly used in the past, are sometimes necessary for resuscitation in shock-induced ventricular fibrillation in normothermic dogs. Kirby, Jensen, and Johnson [5] have found resuscitation after shock-induced fibrillation more difficult in the hypothermic dog. They were able, however, to accomplish this in all animals by single or repeated electric shocks with 220 volts, followed by massage and intracardiac epinephrine when required. In our experiments 170 volts for one-tenth of a second was found to constitute an effective shock.

The use of weak epinephrine solution administered into the heart for conversion of a weak fibrillation to a strong one with good cardiac tone is of real value. Lewis † has also used epinephrine in this manner, with success.

Sinoauricular node blockade appears to be of some value in the prevention and treatment of ventricular fibrillation under the conditions of the experiments reported. Of four animals treated with procaine block of the sinoauricular node prior to the expected onset of fibrillation, fibrillation failed to occur in one and in three it developed in from four to five and one-half minutes after the injection of air. In contrast, 16 animals treated otherwise in the same manner developed ventricular fibrillation in from a few seconds to three and one-half minutes. Perhaps more striking was the apparent effect of sinoauricular node blockade in preventing recurrence of fibrillation once it has been abolished and a normal rhythm had been restored.

By use of the principles established by this study it has been possible in the two instances in which it has been tried to perform a wide left ventriculotomy with occurrence of gross air embolism and to bring about successful resuscitation and long-term survival.

† Lewis, J. F., personal communication to the author.

SUMMARY

The reported experiments indicate that there are effective methods for clearing the coronary arteries of air and conversion of ventricular fibrillation to a normal rhythm under hypothermic conditions. As in all circumstances in which effective heart action ceases, it is necessary to maintain a good airway and a good supply of oxygen to the lungs. It is also necessary to maintain good circulation by effective cardiac massage. Vigorous cardiac massage with cross clamping of the ascending aorta is frequently successful in clearing the coronary arteries of air. When terminal branches of the coronary arteries remain blocked by small bubbles of air, they can be cleared by milking the air out after cutting across the terminal branch of the blocked coronary artery. Electric shock seems more effective in bringing about a cessation of ventricular fibrillation and a restitution to a normal rhythm when applied to a strongly fibrillating heart and less effective in the presence of weak ventricular fibrillation. Intracardiac injection of a weak solution of epinephrine will convert a weak to a vigorous fibrillation. Sinoauricular node blockade may be of some value in the prevention of fibrillation when air embolism occurs and seems to decrease the likelihood of recurrence of fibrillation once it has been abolished and normal rhythm has been restored.

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The Relationship of an Elevated Blood Sugar to an Electrolyte Imbalance

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An elevated blood sugar in the postoperative period, or in relation to the so-called alarm reaction, has been referred to by many authors.*

Our observations have led us to believe, in addition, that a finding of an elevated blood sugar often has a significant relationship to an electrolyte imbalance. These findings have been recorded,† though their corollary significance has not been adequately emphasized. In order to demonstrate the relationship of an elevated blood sugar to an electrolyte imbalance, we present the following study.

METHOD OF STUDY

Among 92 nondiabetic patients undergoing extensive major surgery (mostly gastric and colon resections for cancer or ulcer), serial electrolyte and blood-sugar studies were done every second or third day until the patient was again able to eat food. Three hundred thirty-two complete studies were done. This is a selected group of patients in that most of them posed a nutritional problem incident to their disease, and it might therefore be expected that many of them would experience an electrolyte imbalance. During the period of observation, these patients were fed parenterally.

The studies consisted of serum sodium and potassium determinations done on the flame photometer. The CO_2-combining power was determined by the Van Slyke volumetric method. Blood chlorides were studied by the Shales and Shales method. Blood-sugar determinations were done by the Benedict method.

The findings were evaluated in relation to the severity of the electrolyte imbalance and also in relation to the blood-sugar level.

When no electrolyte imbalance was pronounced, all of the electrolyte values were found to lie within the normal range (chlorides 98 to 108 mEq/Liter, CO_2-combining power 22 to 32 mEq., potassium 3.5 to 5.5 mEq., sodium 134 to 150 mEq.) (Fig. 1).

An insignificant electrolyte imbalance was considered to be one in which these figures were only slightly above or below normal values in one or more of the items (CO_2 18 or 36, chlorides 94 or 113, sodium 130 or 152) (Fig. 2).

A definite electrolyte imbalance was indicated when more than one of the electrolyte items were significantly beyond the above figures (Fig. 3).

The blood-sugar levels were considered to be significantly elevated when the value was above 180 mg. per 100 cc. This figure was used because in some instances the patients did not have their blood-sugar determinations done after the complete fasting period. Furthermore, it has been previously determined that the blood sugar

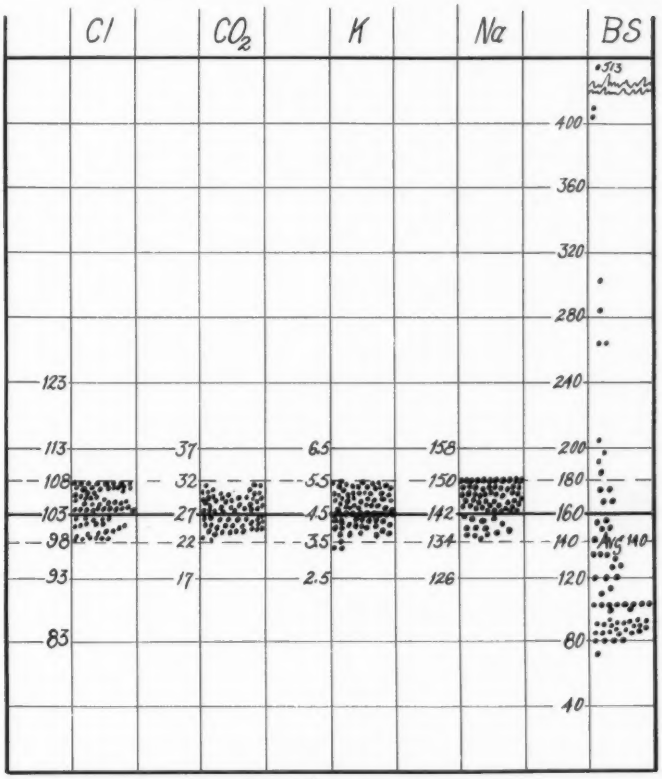
Submitted for publication June 28, 1955.

Funds in support of this study have been provided, in part, by Robert Herwick, M.D., Medical Director, Baxter Laboratories, Inc., Morton Grove, Ill.

Associate Clinical Professor of Surgery (Dr. Rice) and Clinical Instructor of Surgery, University of Minnesota (Dr. Strickler); Resident in Surgery, St. Barnabas Hospital (Dr. Azeris).

* References 1-5, 10.

† References 6, 7, 8.



67 Determinations

No Electrolyte Imbalance

fig. 1.

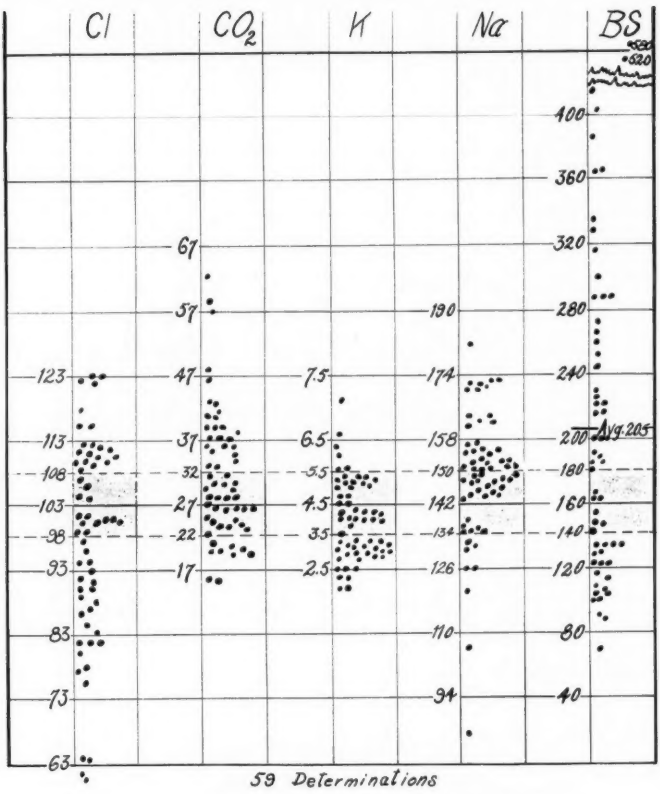
does not usually rise above 180 mg. per 100 cc. when invert sugar or dextrose is being given, and it has also been shown that the blood sugar falls to near normal within an hour or two after the intravenous sugar has been discontinued.

CLINICAL MANIFESTATIONS

There was no specific set of symptoms in these patients which would have suggested a disturbance in the carbohydrate metabolism, and, except for the fact that the blood-sugar tests were being done as a part of an investigative problem, the elevated blood sugar would have gone undetected. In some instances the urine showed a trace or more of sugar, but these findings were not commensurate with the elevation of the blood sugar.

In the cases showing an insignificant electrolyte imbalance, no specific symptoms were evident.

In the cases showing severe electrolyte imbalance the symptoms were variable and by themselves not consistent enough to be diagnostic of any specific electrolyte imbalance. It was observed that a hypochloremic alkalosis associated with ileus and abdominal distention usually signalized a low potassium. Hypochloremic acidosis with weakness, confusion, oliguria, and an irregular pulse was very often associated with a low sodium



Definite Electrolyte Imbalance

fig. 2

and a high potassium. Hyperchloremia, whether with acidosis or alkalosis and when associated with weakness, restlessness, and a rapid pulse, usually indicated a hemoconcentration and a high sodium.

These clinical symptoms, however, were not our primary concern in this study.

THE ELECTROLYTE IMBALANCE IN RELATION TO THE BLOOD-SUGAR LEVEL

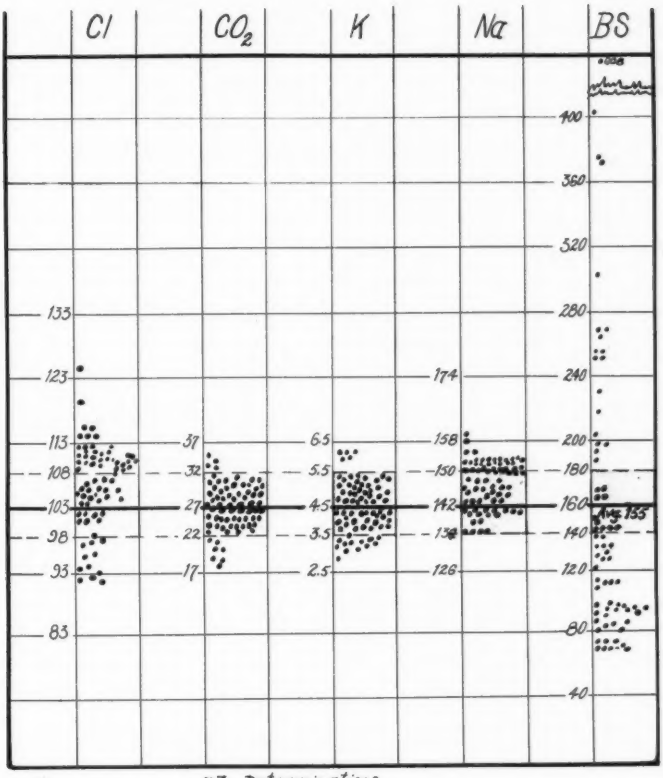
When the figures were grouped in accordance with the blood-sugar level above or below 180 mg. per 100 cc., an electrolyte imbalance was found in 80% of the high blood-sugar group and in 63% of the "normal" blood-sugar group (Table 1).

By employing the Edgerton-Paterson distribution table,[9] we found that a statistically significant difference exists between the two groups, that the higher the blood sugar the more likely an electrolyte imbalance may be found.

When the blood-sugar determinations were evaluated in progressive units of 40, the electrolyte imbalance increased progressively (Table 2).

TABLE 1.—*The Incidence of an Electrolyte Imbalance in Relation to the Blood Sugar*

Blood Sugar, Mg./100 Cc.	Instance of Electrolyte Imbalance	Instance of No Electrolyte Imbalance
Above 180 mg. per 100 cc..	83 (80%)	21 (20%)
Below 180 mg. per 100 cc..	145 (63%)	83 (37%)



Insignificant Electrolyte Imbalance
fig. 3

The ratios of each group, one to another, are not all statistically significant. However, Group 2, as compared with Group 3, is significant; likewise Group 4, as compared with Group 5, is significant. Groups 1 and 7 have too few numbers of cases to be evaluated. The progression of increased incidence of electrolyte imbalance upward with the blood-sugar elevation is in itself an indication of true difference.

TABLE 2.—*The Progressive Increase in the Incidence of Electrolyte Imbalance as the Blood Sugar Rises*

Group	Blood-Sugar Range, Mg./100 Cc.	Instance of Electrolyte Imbalance	Instance of No Electrolyte Imbalance
1	Below 80	19	2
2	80-120	61 (54%)	51
3	121-160	51 (68%)	24
4	161-200	28 (75%)	9
5	201-240	20 (87%)	3
6	241-400	42 (80%)	10
7	Above 400	7	5

BLOOD SUGAR IN RELATION TO THE SEVERITY OF ELECTROLYTE IMBALANCE

When the blood-sugar determinations were evaluated in relation to the severity of the electrolyte imbalance, an elevated blood sugar was even more consistently observed in the definite imbalance cases, as indicated in Table 3.

TABLE 3.—*The Average Blood Sugar in Three Groups of Patients, i. e., Severe, Insignificant, and No Electrolyte Imbalance*

	Definite Electrolyte Imbalance, 59 Determinations, Mg./100 Cc.	Insignificant Electrolyte Imbalance, 73 Determinations, Mg./100 Cc.	No Electrolyte Imbalance, 67 Determinations, Mg./100 Cc.
Av. blood sugar.	205	154	140

THE INCIDENCE OF ELEVATED BLOOD SUGAR IN THE POSTOPERATIVE PERIOD

An analysis of 200 consecutive simple surgical cases revealed an elevation of the fasting blood sugar above 180 mg. 24 hours after operation in only 6 instances. None of the electrolyte levels of these patients was considered to be serious or extensively major. All of these patients had received glucose or invert sugar in the immediate postoperative period.

The 92 patients under consideration in this study who were undergoing serious major operations or disease showed a much higher incidence of elevated blood sugar. Of a total of 332 determinations 104 instances demonstrated an elevation above 180 mg. of blood sugar per 100 cc. The high incidence of elevated blood sugar in this group is no doubt due to the serious nature of the operation and illness, for it was not observed in the 200 uncomplicated surgical cases.

TABLE 4.—*The Patient Incidence of Electrolyte Imbalance When the Blood Sugar Was Above 180 Milligrams per One Hundred Cubic Centimeters*

Blood Sugar Above 180 Mg./100 Cc. (43 Patients)		
Definite Electrolyte Imbalance	Insignificant Electrolyte Imbalance	No Electrolyte Imbalance
28 cases (65%).....	11 cases	4 cases

TABLE 5.—*The Patient Incidence of Electrolyte Imbalance When the Blood Sugar Was Below 180 Milligrams per one Hundred Cubic Centimeters*

Definite Electrolyte Imbalance	Insignificant Electrolyte Imbalance	No Electrolyte Imbalance
10 cases (20%).....	22 cases	17 cases

Of the 92 patients with major operation or disease, 43 showed an elevation of the blood sugar above 180 mg. per 100 cc. and all but four of these presented an electrolyte imbalance at some time during the course of their convalescence. The greatest percentage of these was in the definite electrolyte imbalance group (Table 4).

Among the remaining 49 patients in which the blood sugar was below 180 mg. per 100 cc., the greatest percentage showed an insignificant or no electrolyte imbalance (Table 5).

Tables 4 and 5 reveal the same findings as indicated in Table 1, with the addition of the breakdown into a third group of more insignificant electrolyte imbalance. The breakdown also reveals a definite statistically significant difference between the two groups. Again these findings illustrate that a definitely greater incidence of significant electrolyte imbalance is associated with an elevation of the blood sugar.

THE VALUE OF BLOOD SUGAR, THE CO_2-COMBINING POWER, AND THE BLOOD CHLORIDES AS A LABORATORY UNIT

The preceding paragraphs have illustrated that an elevated blood sugar is frequently associated with a disturbance in the electrolyte imbalance. No set pattern of electrolyte imbalance is predictable, though some tendencies appear to prevail. The greater the elevation of the blood sugar, usually, the severer the electrolyte imbalance.

Hypochloremic alkalosis usually signalizes a low potassium level.

Hypochloremic acidosis usually signalizes a low sodium and a high potassium level. Hyperchloremia with alkalosis or acidosis is frequently associated with a high sodium level. It may signify hemoconcentration.

When both the CO_2-combining power and the chloride determinations were normal, a disturbance in the sodium, potassium, and blood sugar was, as a rule, insignificant.

COMMENT AND CONCLUSIONS

It is suggested that, when a search is being made for a possible electrolyte imbalance, a determination of the blood sugar should be done along with a CO_2-combining power and a blood chloride determination. A disturbance in all three of these items indicates the need for further electrolyte studies, since there is a higher incidence of electrolyte imbalance associated with a high blood sugar than is found when the blood sugar is not significantly elevated.

These studies suggest that the incidence of an electrolyte imbalance increases progressively as the blood sugar rises, or perhaps this should be expressed conversely.

The incidence of postoperative elevation of blood-sugar levels is not predictable on the basis of this study, though it would appear to be a definite entity. Our observations have led us to believe that it occurs infrequently in the uncomplicated surgical illness but that it is frequently observed in the more seriously ill patient.

The elevation of the blood sugar signalizes a disturbance in the electrolyte metabolism as well as a disturbance in the carbohydrate metabolism.

On the basis of the observations which have been evaluated in this manuscript, we have been able to favorably influence an electrolyte imbalance by treating the patient with insulin and a polyionic solution of invert sugar. The details of treating an electrolyte imbalance in this manner will be dealt with in a subsequent manuscript.

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Use of Hydrocortisone After Anorectal Surgery

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The relief of pain after anorectal surgical procedures continues to be a problem. Although improvements in technique have provided some alleviation, the usual approach is still not completely satisfactory. It is the purpose of this paper to present a series of 50 cases treated with the local application of hydrocortisone ointment in which more encouraging results have been obtained.

MATERIALS AND METHODS

It must be stressed that these cases represent only personal clinical observations. No laboratory data other than those routine for such cases were obtained.

All the cases were treated by surgery for hemorrhoids, fissures, fistulas, and combinations thereof. In each case there was the common denominator of removal of mucous membrane and skin. Particular attention was paid to the removal of adequate skin for drainage purposes in each case.

Two products were employed: an ointment containing 1% hydrocortisone acetate with 0.5% neomycin sulfate (Neo-Cortef ointment, Upjohn), and an ointment containing 1% hydrocortisone acetate with 3% oxytetracycline (Terramycin) hydrochloride (Terra-Cortril ointment, Pfizer). The products employed were divided equally in the series in all phases.

In the first 10 cases, the ointment was applied from the fifth to the seventh days postoperatively. This program was discontinued because of somewhat disappointing results. In the next 40 cases the ointment was applied from the first to the fifth days postoperatively.

The total amount of product used in any case was 5 gm. This represents 0.05 gm. of hydrocortisone as the total dose. The product was applied twice daily in divided doses by the patient. Either the bare finger or a pledget of cotton was employed. Application was entirely to the external skin. All patients in this series who were subjected to hemorrhoidectomy were treated by a modified Milligan-Morgan technique. Fissures were treated by the method of Gabriel.

Submitted for publication May 6, 1955.

RESULTS

Encouraging results were obtained in the latter series of 40 cases as compared with both the previous 10 cases and the earlier patients not treated by this method. The results were as follows: 1. The usual skin edema was absent if proper surgical technique was employed. 2. Second-day sphincter spasm almost entirely disappeared. 3. Tab formation was absent. 4. There was no formation of subcutaneous fibrosis, i. e., soft scars resulted. 5. The patients reported remarkable comfort in the second week after operation and a quicker return to gainful occupation with usual duties. 6. Healing was more rapid.

Types of Operations Performed in the Forty More Successful Cases

	No. of Cases
Hemorrhoidectomy	32
Fistulectomy	1
Fissurectomy	1
Hemorrhoidectomy with repair of fissure or fistula	6
Total	40

COMMENT

Pain following anorectal surgery has been better controlled by the newer surgical techniques. Patients no longer need suffer intense pain for a prolonged period. They do, however, continue to have disabling discomfort which in many instances prevents gainful employment for two to four weeks. It was

the purpose of this study to eliminate the latter to some degree. Previous attempts have consisted of local application of anesthetics in ointment form, injection of oil-soluble anesthetics, and, recently, injection of a slowly released procaine derivative.

The best results in this series were obtained in the treatment of hemorrhoids. In a large number of my cases prior to the use of hydrocortisone, I noted that edema of the skin along the lines of incision occurred starting on the third day. Since one is dealing with a circular structure, of necessity the skin islands between the lines of incision became swollen as well. Secondary to edema formation, sphincter spasm frequently occurred. Although this phenomenon varied from patient to patient, it was present in all to some degree. The amount of edema influenced the healing time and the period of disability. It also bore a direct influence on the formation of redundant skin tabs.

Since hydrocortisone is believed to have an anti-inflammatory action and inhibitory effect on fibrous tissue formation, it was felt that its use might be beneficial after anorectal surgery. Reduction of edema, and thereby relief of pain, with the local application of small doses has previously been observed in cases of pruritus ani. The exact physiological mechanism is not fully understood. In view of these facts, it was decided to apply this ointment locally after anorectal surgery.

The best results were observed after hemorrhoidectomies, since these cases involve removal of the greatest amount of skin and mucous membrane. Encouraging results were also obtained after fissurectomy and fistulectomy.

This study is only a humble beginning. It is felt that the application of the principle in greater strengths and possibly by other means may hold more promise.

CONCLUSIONS

One per cent hydrocortisone ointment was applied topically for the first five days following anorectal surgery.

Reduction in edema formation, better alleviation of pain, and a quicker return to gainful employment occurred.

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Arterial Replacement with Rectus Fascia

An Experimental Study

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and
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Since arterial homografts are not universally available, it would be advantageous to have a method to repair arterial defects utilizing available autogenous tissue. The reports of Neuhof,[2] Peirce,[3] and Cousar and Lam [1] suggested that posterior rectus fascia was a satisfactory substitute for arterial repair, but limited experiments and short periods of observation suggested that additional studies were necessary prior to clinical application of the method.

METHOD

Seventy-six mongrel dogs, weighing 7 to 25 kg., were used in the experiment. Intravenous pentobarbital sodium was used as the anesthetic agent. The abdomen was surgically prepared and then entered through a lower midline incision. The rectus fascia was exposed and a strip of fascia removed from either the anterior rectus sheath, posterior rectus sheath, or posterior rectus sheath with attached peritoneum for repair of the arterial defect in the "patch graft" series. Posterior rectus sheath and peritoneum were used exclusively in the "tube graft" series. The fascia was placed in a solution containing isotonic saline, penicillin, and 10 units of heparin prior to implantation. The peritoneum overlying the aorta was incised and the vessel mobilized from the renal arteries to the bifurcation.

In Series 1 oval defects measuring 1.5 to 3 cm. in length and 0.5 to 0.9 cm. in width were created in the anterolateral wall of the abdominal aorta. The defect resulted in the removal of 50% to 75% of the total vessel circumference. The defect was closed with either anterior rectus sheath or posterior rectus sheath, with the underlying peritoneum of appropriate length and width to cover the defect. The graft was secured by quadrangulating everting 00000 nonabsorbable surgical (silk) sutures and marginal closure accomplished with a continuous over-and-over 00000 nonabsorbable surgical suture.

In series 2 fascial tubes varying in length from 1.0 to 4.0 cm. were constructed over glass tubes which were slightly smaller in diameter than the recipient aorta, utilizing an inner continuous mattress suture and an outer over-and-over layer of 00000 silk. Total defects were created in the abdominal aorta by resecting a segment 1 cm. in length shorter than the formed tube graft. End-to-end anastomosis was done using a triangulating suture and a continuous over-and-over mattress suture of 00000 silk.

The peritoneum was closed overlying the site of grafting in all cases. Bleeding at the site of grafting was minimal and controlled by local tamponade.

TABLE 1.—*Patch Fascia Grafts of the Abdominal Aorta of the Dog*

Total Grafts 36 Dogs	
Rupture and hemorrhage	3
Thrombosis	1
Aneurysm (22 mo.)	1
Complication total—5 or 13.8%	

Penicillin was given intramuscularly during the postoperative period. Femoral pulsations were checked daily for one month postoperatively.

RESULTS

SERIES 1.—Patch grafts were inserted in the abdominal aorta of 36 animals (Table 1). In the initial 10 animals of the series spontaneous rupture of the graft with fatal hemorrhage occurred in 3 cases in the first postoperative week. Thrombosis occurred in the immediate postoperative period in one animal, with loss of femoral pulsations but with recovery of pulsations in 21 days. Eighteen animals died of causes unassociated with the operative procedure within 12 months after operation. Eight animals died or were killed

Submitted for publication Aug. 26, 1955.

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TABLE 2.—*Fascia Patch Grafts of the Abdominal Aorta in Dogs*

Dog No.	Observation Time, Mo.	Preoperative Graft Measurement	Final Graft Measurement
1	20	8 mm. × 6 mm.	11 mm. × 5 mm.
2	25	13 mm. × 8 mm.	25 mm. × 5 mm.
3	27	10 mm. × 5 mm.	19 mm. × 7 mm.
4	27	10 mm. × 5 mm.	13 mm. × 6 mm.
5	27	19 mm. × 6.5 mm.	23 mm. × 6 mm.
6	28	12 mm. × 3 mm.	18 mm. × 8 mm.

from 12 to 24 months postoperatively revealing no thrombosis or dilatation. A single saccular aneurysm was found 22 months postoperatively, which appeared as an outpouching through the central portion of the graft indicating a local area of weakness. Eight animals survived 24 or 29 months and were killed. No dilatation or aneurysm formation was found. One specimen from the animal with recorded loss of femoral pulsations during the first 21 postoperative days was patent, although the lumen was slightly narrowed at the point of grafting by cicatricial bands extending between adjacent points in the vascular wall.

Although each "patch" graft when completed appeared flattened in the posteroanterior diameter, this change was not apparent at the time of final observation. In general, the grafts had lengthened and increased slightly in width at the time of final observation as compared with the operation measurement, indicating an adaptation of the fascia to the surgically created arterial defect (Table 2). All grafts were thin and pliable and covered by a shining white intima-like lining. The gross appearance of the grafts examined from 6 weeks to 28 months after implantation was essentially the same.

SERIES 2.—In 20 animals fascial tube grafts less than 8 mm. in diameter were inserted in total aortic defects (Table 3). Thrombosis was the cause of failure in 11 animals and spontaneous rupture with fatal hemorrhage occurred in four instances. One aneurysm was observed in an animal surviving 15 months. One animal was found to have a thrombosed graft three months postoperatively, despite the presence of excellent femoral pulsations throughout the entire postoperative period. Only four grafts of this series were considered to be successful after periods of observations of 7 days, 11 days, 2 months, and 6 months. Complete endothelization of the grafts was observed from two to six months.

TABLE 3.—*Fascia Tube Grafts of the Abdominal Aorta in the Dog—Complication in Twenty Grafts*

Diameter < 8 mm.	
Thrombosis	11
Rupture and hemorrhage	4
Aneurysm (15 mo.)	1
Complication total—16 or 80%	

In 20 dogs with fascial tube grafts 8 mm. or more in diameter (Table 4) no early or late thrombosis occurred. There was one death due to spontaneous perforation of the graft adjacent to the suture line. In one animal the graft was found to be dilated distal to a stenosis at the proximal suture line. Of three animals observed 12 to 16 months, a fusiform aneurysm was found 16 months postoperatively in one and a small aneurysmal sac was present in the proximal portion of the graft in another. In two of four animals observed for 6 to 12 months, aneurysmal changes were observed in two at 6 and 7 months postoperatively.

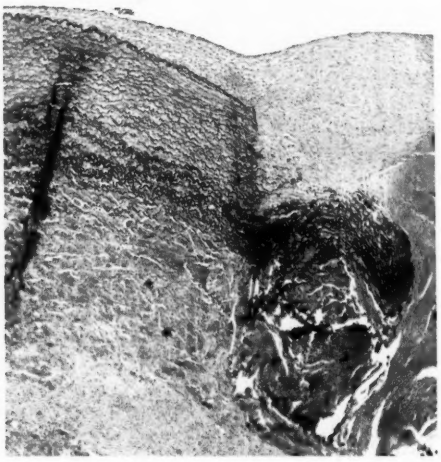
TABLE 4.—*Fascia Tube Grafts of the Abdominal Aorta in the Dog—Complications in Twenty Grafts*

Diameter > 8 mm.	
Thrombosis	0
Rupture	1
Aneurysm (6-16 mo.)	4
Poststenotic dilatation	1
Complication total—6 or 30%	

GROSS AND MICROSCOPIC OBSERVATIONS

In grafts observed for one to seven days after operation, the inner layer of the graft was covered by a thin red coagulum. In 14 days a whitish membrane could be seen covering the suture line migrating toward the central portion of the graft but leaving a small area of central red coagulum. In 21 days the graft was usually covered by a

complete intima-like lining. The graft assumed the approximate thickness of the adjacent aorta, and in specimens observed form 20 to 28 months the graft remained soft and pliable. When the aorta was removed and longitudinally opened after the animal was killed, the fascial graft was thrown into folds indicating lack of elasticity, as compared with the adjacent contracted aortic wall. The gross appearance of all successful tube grafts was essentially the same, although complete development of lining membrane was delayed and was observed to be incomplete at 21 days after implantation, as contrasted with the patch grafts.



Fascial graft to the abdominal aorta (Dog No. 1480, 14 days postoperatively).

Fibroblastic ingrowth was seen originating along the margin and outer surface of the graft. The maximal activity was along the margins of the defect, and here a layer of lining cells were seen to form an intima-like membrane (Figure). This appeared to be an adaptation of the underlying fibroblasts. Elastic tissue stains revealed an absence of elastic fibers in the fascial graft. Microscopic examination of the grafts at 20 to 28 months following implantation revealed a hyalinizing fibrous tissue replacement of the graft, without thickening or calcification.

COMMENT

Anterior rectus fascia and posterior rectus fascia with and without peritoneum served as a satisfactory substitute for the closure of partial arterial defects, with a failure rate of 13.8% in 36 animals (Table 1). Three spontaneous ruptures of the graft occurred in the early postoperative period in the initial group of 10 animals. It was believed that this represented a technical defect rather than an inherent weakness of the homologous tissue. Aneurysm formation occurred in one instance at 22 months postoperatively and appeared as a saccular projection from the central portion of the graft, indicating local weakness rather than a fusiform pouching, as found in the tube graft series. It was postulated that the remaining elastic arterial wall at the site of the patch graft absorbed the major effect of arterial thrust and thereby minimized stress upon the fascial graft, eliminating dilatation and aneurysm formation, as observed in the tube graft series.

The incidence of spontaneous thrombosis and rupture with or without thrombosis was high (Table 3) and occurred in 75% of the tube grafts inserted into aortas measuring 8 mm. or less in diameter. This usually occurred within six hours of surgery. The reason for the high incidence of thrombosis is not apparent from this study but is possibly associated with the technical difficulties of anastomosing a small diameter graft.

When the aorta and graft measured 8 mm. or more in diameter, the immediate success rate was high, with no recorded thrombosis and only a single rupture in 20 animals (Table 4). However, aneurysm formation was found in four animals surviving 6 to 16 months.

CONCLUSION

This study suggests that lateral partial arterial defects can be successfully closed with autogenous fascia, with a high immediate and late success rate. The high incidence of thrombosis in arteries 8 mm. or less in diameter following total segmental

arterial replacement with fascia discourages clinical application of the method. When fascial tube grafts were used to replace excised segments in arteries 8 mm. or more in diameter, the immediate success rate was high, but late appearance of aneurysmal dilatation indicates that the method should be used only when homologous grafts or synthetic substitutes are not available. If circumstances should necessitate the use of fascia for arterial repair, for either a complete or an incomplete defect, it would appear necessary to reinforce the grafted segment with an outer reinforcing layer of fascia.

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Traumatic Injuries of the Gall Bladder

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Traumatic perforation of the gall bladder is infrequent, occurring in approximately 2% to 3% of all patients with abdominal injury (Table 1). The possibility of damage to this organ must be considered, however, as failure to recognize its existence may result in fatality, whereas the operative management is usually attended with good results. Most reports from civilian hospitals within recent years contain only isolated case presentations. It therefore seemed appropriate to evaluate this type of injury in a city-county hospital where a large number of abdominal injuries are treated.

TABLE 1.—*Incidence of Injury to the Gall Bladder in Abdominal Trauma; Collected Data*

Author	Patients with Abdominal Trauma, No.	Patients with Injury to Gall Bladder, No.	Incidence, %
Lowdon [1]	64	0	0
Stout [2]	318	3	0.9
Giblin [3]	76	2	2.6
Eaton [4]	209	7	3.3
Madding, Lawrence, & Kennedy [5]	3,154	51	1.6
Gordon-Taylor [6]	600	2	0.3
Sako & others [7]	384	33	8.6
Sparkman & Fogelman [8]	100	2	2.0
Total	4,905	100	2.0

MATERIAL

A review of the records of all patients treated for traumatic wounds of the abdomen at Jefferson Davis and Veterans Administration Hospitals for the 15-year period ending 1955 revealed that 25 patients had sustained an injury to the gall bladder. Fourteen (56%) of the injuries were due to bullets, nine (36%) to stab wounds, and two (8%) to blunt trauma (Table 2). One of the latter two patients was struck by an automobile; the other was kicked during a fight. The incidence of associated visceral injury was high. In 18 cases (72%) there was a co-existent hepatic injury, in 9 (36%) the small bowel was perforated, and in 8 (32%) there was a concomitant injury of the colon. In only five patients (20%) was the gall bladder the only viscus damaged.

Most of these patients arrived in the emergency room in a state of profound shock secondary to the trauma and blood loss.

TREATMENT AND RESULTS

Following immediate resuscitation, laparotomy was routinely undertaken. The management of the injured gall bladder varied, but in general treatment was directed toward preservation of the gall bladder when feasible, cholecystectomy being performed in only 14 instances (56%). In most of the latter instances the gall bladder had been extensively damaged. Three patients who were injured by bullets were treated by cholecystostomy. In eight (32%) it was possible to repair the viscus by simple suture. Six of the latter patients had been injured by stab wounds and two by missiles. No serious injuries of the extrahepatic bile ducts were noted. One patient had a contusion of the common bile duct, and this was treated uneventfully by decompression with a T-tube. Drainage of the region of the gall bladder was routine.

Twenty patients (80%) survived the injury, and although complications developed

Accepted for publication Sept. 3, 1955.

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in five of these, the end-results were gratifying. These complications consisted of evisceration (two patients), intraperitoneal abscess (two patients), and fecal fistula (one patient). No biliary fistulas developed.

All of the patients who died had sustained multiple injuries involving at least two organs in addition to the gall bladder. One death was due to pulmonary infarction, one to renal failure, and one to massive damage to the liver in addition to a subarachnoid hemorrhage. Two deaths were attributed to hemorrhagic shock. These occurred early in the series and could probably have been prevented by present-day transfusion practices.

Among the six patients treated prior to the availability of antibiotics and adequate blood-bank facilities (1945), the mortality rate was 50%. Thereafter the mortality rate fell to 11%.

TABLE 2.—*Summary of Twenty-Five Patients with Injury of the Gall Bladder*

Patient	Date	Mode of Injury	Associated Injuries	Type of Operation on Gall Bladder	Result
1	1940	Bullet	Liver, duodenum	Cholecystostomy	Died
2	1941	Stab	None	Suture	Good
3	1944	Bullet	Liver, colon	Suture	Died
4	1945	Stab	None	Suture	Good
5	1945	Stab	Liver	Suture	Good
6	1945	Bullet	Liver, stomach	Cholecystostomy	Died
7	1948	Stab	None	Cholecystectomy	Good
8	1948	Bullet	Liver, stomach, colon, duodenum	Cholecystectomy	Good
9	1949	Stab	Liver	Suture	Good
10	1950	Bullet	Colon, cecum, ileum	Suture	Good
11	1950	Bullet	Liver, colon, stomach	Cholecystostomy	Good
12	1951	Bullet	Liver, stomach, colon, jejunum	Cholecystectomy	Died
13	1952	Bullet	Liver	Cholecystectomy	Good
14	1952	Stab	None	Suture	Good
15	1953	Stab	Liver	Cholecystectomy	Good
16	1953	Stab	Liver, diaphragm	Suture	Good
17	1953	Bullet	Liver	Cholecystectomy	Good
18	1953	Bullet	Colon, jejunum, pancreas, kidney	Cholecystectomy	Good
19	1954	Blunt	None	Cholecystectomy	Good
20	1954	Bullet	Liver, colon, jejunum	Cholecystectomy	Good
21	1954	Bullet	Liver, stomach, colon, duodenum, jejunum	Cholecystectomy	Good
22	1954	Bullet	Liver, duodenum, pancreas, kidney	Cholecystectomy	Good
23	1955	Stab	Liver, duodenum	Cholecystectomy	Good
24	1955	Blunt	Liver, subarachnoid hemorrhage; fractures	Cholecystectomy	Died
25	1955	Bullet	Liver, stomach	Cholecystectomy	Good

COMMENT

Little was written about injury to the gall bladder in the 19th century. In one of the earliest reports (1806) Paroisse * wrote of a soldier who died of pulmonary disease two years after being shot in the right upper quadrant of the abdomen. Autopsy revealed the ball to be within the lumen of the gall bladder. No scar was found in the gall bladder wall. During the same period Baron Larrey, writing of his experiences in the Napoleonic Wars (1800-1815), considered wounds of the gall bladder as mortal because of the resulting bile peritonitis.†

The inadequacies of therapy during the Civil War era are summarized by notes on a casualty in the Surgeon General's report of the Civil War.[9]

Case 408. Sergeant W. G. Alleger, Co. G, 142d Pennsylvania, aged 23 years, was wounded at Gettysburg, July 1, 1863. He was treated in the field hospital of the 3d division, First Corps, until the 24th, when he was admitted to Camp Letterman Hospital. Acting Assistant Surgeon W. B. Jones reported that: "A minié ball entered the cavity of the abdomen three inches above and one inch to the right of the umbilicus, passed obliquely to the right and upward, passing through the liver and gall-bladder, and emerged between the sixth and seventh ribs. From the time of injury until decease, large quantities of bile were discharged from the upper

* Paroisse: Opuscules de chirurgie, 1806, cited by Otis.[9]

† Larrey, F. H.: Memo sur les plaies penet. de l'abdomen, Paris, 1845, cited by Gordon-Taylor.[6]

wound: his health seemed to remain good until August 1st, when he began to sink; a severe diarrhoea commenced shortly after reception of the injury and continued until he died, being controlled at intervals by the free use of camphor and opium. The treatment consisted of cold-water dressings to wound, and administration of beef-tea, brandy, and opium. He died August 6, 1863."

As summarized by Giddings [10] and Keen,[11] the concept of management of abdominal wounds underwent a radical reversal early in the 20th century. During the Boer War (1899-1901) the policy of nonintervention in abdominal wounds had continued. By the end of World War I this policy had been abandoned by most surgeons, the majority agreeing that laparotomy should be carried out. During the Spanish Civil War (1936-1939) immediate surgical intervention was the rule when competent surgeons and adequate facilities were available. The fundamental objective in the management of abdominal injuries in World War II was operative repair of wounds as soon as the patient had had adequate preoperative preparation. Madding and his associates [5] summarizing their experiences in World War II, reported 51 injuries of the gall bladder and 2 of the common bile duct (Table 3). Every injury was associated with a wound of the liver. Five of the patients were treated by simple suture of the gall bladder, treatment of the others being equally divided between cholecystectomy and cholecystostomy.

TABLE 3.—*Mortality Rate in Combat Wounds*

Period	Patients, No.	Deaths, No.	Mortality Rate, %
World War I			
American [6]	11	7	64
World War II			
British [6]	5	1	20
2d Auxilliary Surgical Group [5]	51	15	29
Korean Conflict			
Surgical Research Team [7]	33	0	0

Treatment of shock and infection continued to improve during the Korean conflict. As a result there was a steady decrease in the mortality in patients sustaining perforation of the gall bladder resulting from war wounds; hence near the end of hostilities the Surgical Research Team in Korea was able to report 33 patients with cholecystic injury without a fatality.[7]

Most wounds of the gall bladder are associated with wounds of other viscera, for most injuries to this viscus still result from penetrating wounds, despite the increasing incidence of traffic accidents. Therefore, the possibility of bacterial contamination usually exists, and such wounds are potentially very dangerous, since it is generally agreed that infected bile peritonitis is lethal. On the other hand, the problem of sterile bile peritonitis has been a subject for discussion for over 300 years. In 1666 Malpighi ‡ made a biliary fistula in a dog and noted that large quantities of bile could be spilled without serious consequences. Subsequent experiments have produced evidence supporting and disclaiming his results. Two factors peculiar to animal experiments which limit their value in respect to human bile peritonitis are, first, that bile of animals has a different concentration of bile salts and acids and, secondly, that bacteria occur normally in the bile of some animals. In 1934 Mentzer [13] made an extensive review of this subject and developed the thesis that sterile bile is well tolerated by the peritoneal cavity and, that unless secondary infection intervenes, it is not necessarily fatal. One of the most interesting patients demonstrating this point is that reported by Fryer,§ in 1813. A 13-year-old boy was struck in the abdomen by a wagon shaft, after which time the abdomen became swollen. During the ensuing eight weeks a total of 20 liters of bile was removed by repeated aspirations of the abdominal cavity; the patient lived. Other reports demonstrate the ability of the abdominal cavity to encyst bile collections for long periods. Labrosse ‖ reported a patient who had been operated upon by Jaboulay two years after having

‡ Cited by Budd.[12]

§ Fryer: Case of Extravasation of Bile into the Cavity of the Abdomen from Rupture of the Liver or Gallbladder, cited by Mentzer.[13]

‖ Labrosse: Contribution à la étude du cholepéritoine spontane, cited by Mentzer.[13]

been struck in the abdomen by a ladder. Ten liters of bile were found encysted about the gall bladder, which had a small patent opening that had evidently persisted since the time of injury. Norgore [14] made an extensive survey of the literature in 1946, in an effort to collect proved cases of rupture of the gall bladder due to blunt trauma. He was able to find only 32 patients, including 1 whom he reported. Since then, at least six additional patients have been reported in the English literature.¶ Smith [20] (1954) wrote that a fatality from nonpenetrating wounds of the gall bladder treated surgically had not been reported since 1898. In most instances rupture follows a major crushing injury. Occasionally a seemingly trivial injury may tear the gall bladder.[21] It is under these circumstances that one may observe the effect of sterile bile in the peritoneal cavity without additional injuries to cloud the issue. Such experiences apparently confirm the observation that bile peritonitis without infection is not a fulminating disease. In fact, there may be only minimal signs of peritoneal irritation for the first 24 to 48 hours after injury, and in several case reports operation had been delayed because of the paucity of signs and symptoms. One of our patients illustrates this syndrome.

REPORT OF A CASE

A 47-year-old white man was admitted to Jefferson Davis Hospital on July 11, 1954, with a history of having been kicked in the epigastrium 18 hours prior to admission. Epigastric pain had persisted since the injury. He had vomited twice. Physical examination was essentially negative. There was no abdominal rebound tenderness, and peristalsis was present. Roentgenograms of the chest and abdomen were considered normal. While he was under observation during the ensuing 26 hours, his pain increased in severity. By this time his abdomen was rigid and peristalsis was absent. Exploratory laparotomy revealed 200 to 400 cc. of bile which had escaped into the peritoneal cavity from a small perforation of the fundus of the gall bladder. No other organs were injured. Cholecystectomy was followed by an uneventful recovery.

Thus it appears that the peritoneal cavity will tolerate the presence of sterile bile for relatively long periods with a minimal reaction, but there is no doubt that continued leakage of bile is dangerous, for secondary infection may supervene at any time. Consequently, surgical intervention should be instituted whenever this diagnosis is entertained. Our two patients add to the evidence accumulated by Smith, which indicates that the surgical treatment of such lesions is almost uniformly attended by good results.

In this institution all penetrating wounds of the abdomen are explored, and nonpenetrating wounds are explored when physical or roentgenographic findings indicate injury to a viscus or a major vessel. In occasional patients peritoneal taps have been of value in confirming the diagnosis of visceral injury. Associated injuries are corrected as deemed advisable, and the bile, blood, and foreign bodies are removed from the peritoneal cavity.

Three methods of management of the injured gall bladder are available: simple suture, cholecystectomy, and cholecystostomy. Preference is given to simple suture for small wounds and to cholecystectomy when more extensive damage is present. Cholecystostomy is now reserved for only the occasional patient, when, because of the general condition of the patient or the desire to decompress a contused but viable common duct, it appears to be a safer procedure. It has been our practice to drain the area of the gall bladder, fearing secondary hemorrhage or leakage of bile—potential complications which were not observed in this series.

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Morphologic Changes of Intestinal Grafts Used in Bladder Reconstruction

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Reconstruction of the urinary bladder in the experimental animal has been carried out using seromuscular grafts of intestinal origin.* In these studies segments of ileum and colon with intact mesenteric pedicle were stripped of the mucous membrane, reversed so that the serosa faced inward, and sutured to a trigonal remnant. The present study concerns observations on the changes of the aging seromuscular graft, ileal grafts with intact mucous membrane, ileal grafts stripped of the mucous membrane but not reversed, and ileal grafts in which the mucosa and the submucosa were removed, leaving only the raw muscularis facing toward the lumen.

MATERIALS AND METHODS

The technique of bladder reconstruction by means of seromuscular grafts, according to an original method, has been described in detail.[3] Since the first published series of 10 dogs, three additional types of experimental conditions were performed on a total of 31 animals for comparative purposes. These four groups were as follows:

1. Seromuscular grafts with the serosa facing the luminal aspect of the reconstructed bladder.
2. Ileal grafts with intact mucous membrane facing the lumen.
3. Ileal grafts with the mucous membrane scraped off and the raw submucosa facing inward.
4. Ileal grafts with both the mucous membrane and submucosa removed, leaving raw muscularis facing inward.

It should be noted that only in the first group were the grafts reversed so that the serosa faced inward. Except for the modifications outlined above, all procedures were carried out in an identical manner and under comparable circumstances.

Biopsies of the graft of sufficient size and depth were taken at intervals, and necropsy studies were made on all killed animals. Tissues were fixed in 10% formaldehyde solution, embedded in paraffin, and stained by a routine hematoxylin-eosin method.

RESULTS

Histologic Observations of the Aging Seromuscular Graft.—One-Week-Old Graft: The mesothelial cells of the peritoneum making up the lining of the reconstructed bladder are clearly recognized and appear to be well preserved. Also well preserved are the two muscular layers of the transplanted intestinal wall, the inner circular layer having become the outer layer in the reversed seromuscular graft. Beyond this coat there is a well vascularized loose fibrous connective tissue corresponding to the submucosa of the intestinal segment.

Two-Week-Old Graft: The luminal surface of the reconstructed bladder is lined by several layers of cells of the transitional type which resemble in all respects normal

Submitted for publication Aug. 1, 1955.

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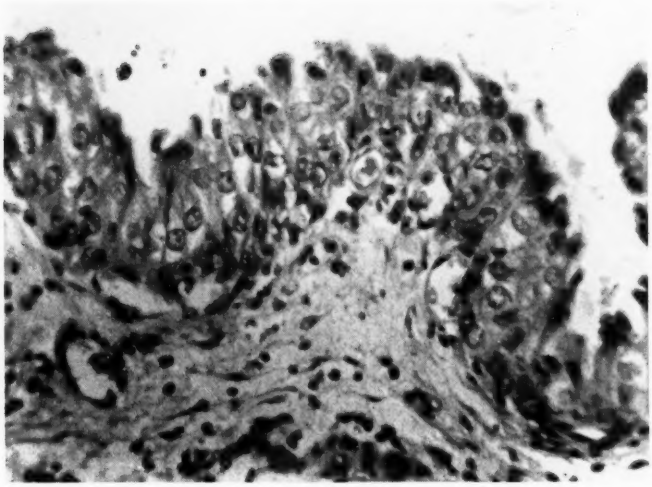


Fig. 1.—Reversed seromuscular ileal graft 15 days postoperatively showing epithelization of the luminal aspect.

bladder epithelium (Fig. 1). This epithelium lies upon a fibrous connective tissue layer rich in both mesenchymal cells and blood capillaries. The two layers of smooth muscle are well demarcated and structurally well preserved. The outer wall of the graft, which corresponds to the submucosa of the transplanted intestine, shows the presence of fairly regularly aligned, flattened, elongated cells provided with small, dark nuclei suggesting mesothelial cells. Large and middle-sized blood vessels belonging to the mesenteric pedicle are seen embedded in this outer layer.

Three-Week-Old Graft: By the end of the third week, stratified epithelium of the transitional type, in a layer from 6 to 10 cells in thickness, regularly lines the cavity of the reconstructed bladder. It includes a basal-cell layer and several layers of pleomorphic cells which become progressively

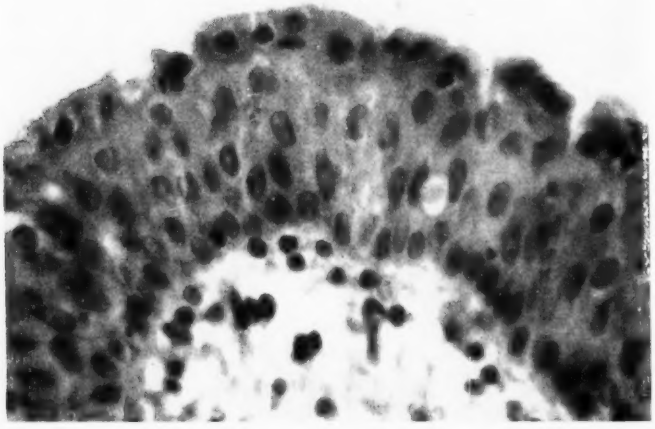
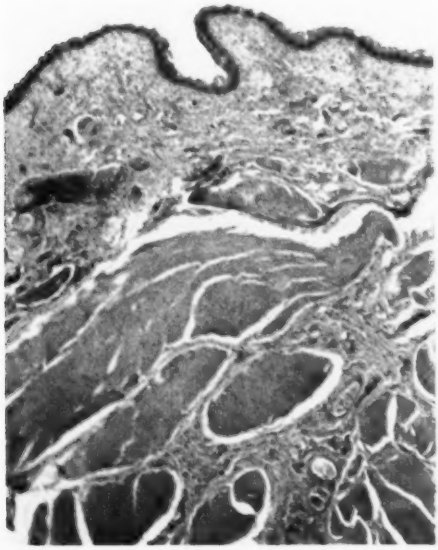


Fig. 2.—Pluristratified, transitional type of epithelium lining the reconstructed urinary bladder, six months after application of reversed seromuscular intestinal graft. Hematoxylin and eosin, × 970.

flatter toward the surface. The nuclei are large, oval, and dark-staining, with strands of chromatin in a network. The cytoplasm is clear, to a pale basophilic. The arrangement of the muscular coat is not clearly made out, as in the previous stage, and it is composed of broken-up, smaller bundles of fibers which run predominantly longitudinally in the inner layer and in circular fashion in the outer layer, with minimal tendency toward interlacing.

Six-Week- to Two-Year-Old Grafts: Presence of inner lining by pluristratified transitional epithelium is shown by old grafts examined within this period (Fig. 2). The breaking up of the two muscular layers of the original transplant into small bundles becomes progressively more pronounced; by the end of the third month there is considerable interlacing of the bundles, resulting in a structure that is indistinguishable from the plexiform arrangement of the detrusor muscle of the normal urinary bladder (Fig. 3).

Fig. 3.—Biopsy of seromuscular graft taken two years postoperatively, showing well-developed transitional-cell lining and interlacing plexiform arrangement of musculature.



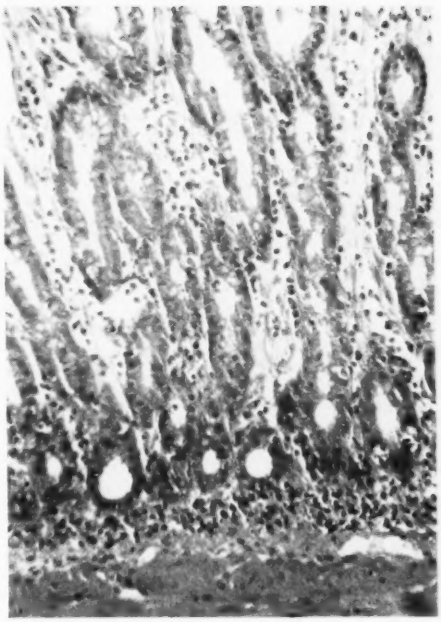


Fig. 4.—Section from biopsy specimen from bladder graft of ileal segment with intact mucous membrane, taken three months postoperatively.

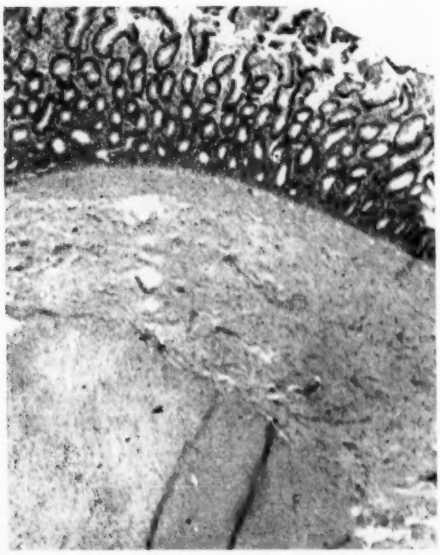
Histologic Observations of Mucous-Membrane-Lined Grafts.—When ileal grafts with the mucous membrane left intact were utilized to reconstruct the urinary bladder, they remained viable. This mucosa, applied to the inside of the bladder, was pink and devoid of ulcerations, but in some instances it was slightly boggy. Sections taken at intervals up to nine months postoperatively showed intact ileal mucous membrane in every instance. There were varying degrees of inflammatory reaction consisting of small round-cell infiltration with some polymorphonuclear leucocytes and eosinophiles in the mucosa (Fig. 4); in several instances this cellular infiltration penetrated the submucosa. The two muscle layers of the original intestinal segment remained intact and unaltered throughout the period of observation.

Observations of the Ileal Grafts with Mucous Membrane Scraped Off.—Bladders were reconstructed with segments of ileum

in which the mucous membrane was scraped off until little or no mucosa appeared on gross inspection. The raw submucosa when applied to the luminal aspect of the bladder, in our hands, was invariably found to regenerate ileal mucous membrane (Fig. 5). This mucous membrane resembled normal ileal mucosa in every respect, except for occasional inflammatory reaction; from the histologic standpoint they were comparable to the grafts in which the mucosa was left intact. It was believed that it would be impossible or nearly impossible to eradicate entirely the mucous membrane without removing the submucosa. Persistent small islands or nests of mucosal cells, which are deeply situated, probably remain viable despite all efforts to eradicate them; these form the basis for the regenerating ileal mucosa.

Observations of Ileal Grafts with Both Mucosa and Submucosa Removed.—When ileal grafts were stripped of both mucosa and submucosa, a very thin, flimsy structure resulted. These grafts utilized for bladder reconstruction were found to be lined with transitional epithelium in a manner similar to that of the reversed seromuscular grafts. In one instance small areas of osteoid tissue were found. Early biopsies on these grafts, however, when taken in comparable direction and alignment, show thicker inner circular muscle layer of the original ileal segment to be toward the inner aspect of the reconstructed organ, in contrast to the relative positions in the reversed graft. The muscular layers of this type of graft were found to break up into small bundles, and these smaller bundles then assume a plexiform arrangement similar to that described for the reversed seromuscular graft (Fig. 6).

Fig. 5.—Section from biopsy specimen of ileal segment from which the mucous membrane had been stripped off, taken 75 days postoperatively. Slide shows regeneration of ileal mucosa and intact intestinal musculature.



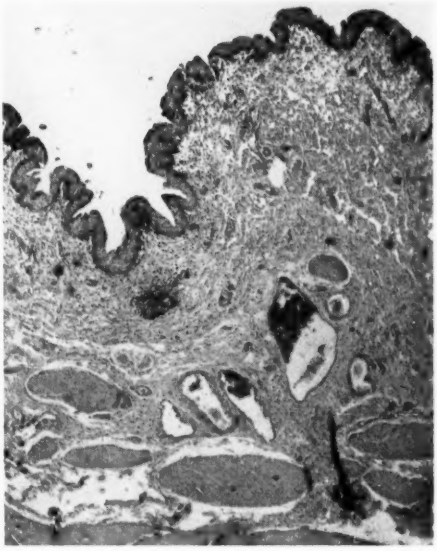


Fig. 6.—Section from biopsy specimen of seromuscular graft with raw muscularis facing into the lumen, taken 56 days postoperatively. Note transitional-cell epithelium and beginning break-up of intestinal muscularis into small bundles.

SUMMARY AND CONCLUSIONS

Epithelization of the luminal aspect of the reversed seromuscular graft was noted in all cases with growth of a transitional epithelium indistinguishable from normal bladder mucosa. Epithelization occurred rapidly and was noted to line completely the lumen

of the reconstructed bladder in a two- to three-week interval. A gradual change in the muscular structure of this graft occurred with loss of arrangement of the two muscular layers of the intestinal segment and formation of small interlacing bundles giving a plexiform appearance. This change is interpreted as an adaptation of the muscular tissue brought about by physiological demand. Peritonealization of the raw outer layer of the introduced seromuscular graft was noted.

Comparison between this graft and three other methods in which the grafts were not reversed was made. Grafts in which the mucosa was left remained intact throughout the period of observation. Grafts in which the mucosa was scraped off were found to regenerate the ileal mucosa. Grafts in which the mucosa and submucosa were removed, although technically more difficult to handle, gave results comparable to those with the reversed seromuscular grafts.

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Editorials

SOME ADVANTAGES OF OPERATIVE CHOLANGIOGRAPHY

SINCE operative cholangiography * was first described by Mirizzi, in 1932, it has proved to be of inestimable aid to the surgeon, with ultimate benefit to the patient. The real advantages of operative cholangiography are (1) to detect calculi in the intrahepatic and extrahepatic ducts; (2) to differentiate dysfunction of the sphincter of Oddi (i. e., transitory or prolonged spasm), hypertrophy, inflammation, and eventual fibrosis; (3) to differentiate pancreatitis from tumor; and (4), in secondary operations of the biliary tract, to enable the operator to become anatomically oriented in planning surgery with a minimum loss of time.

These advantages, together with the fact that this procedure is readily adaptable to any operating room, have been well documented in the literature by Mirizzi, Mallet-Guy, Partington and Sachs, Mixter, Hermanson and Segel, and Norman. For this procedure, as in many others in the field of medicine, wholehearted cooperation is required of the surgeon, radiologist, anesthetist, x-ray technician, and operating nurse. Each part is important and must be followed accurately, in order to achieve successful results. It is true that in the early phases of development the procedure was not readily accepted owing to inadequate x-ray equipment, as well as to a lack of interest on the part of any single member of the team.

However, during the last few years a decided improvement has been made in the x-ray equipment used in surgery, grid cassettes, portable Bucky, and changes in the surgical tray setup. Serial films, i. e., three exposures per 3 cc. injection done under physiologic conditions are of definite value over a single injection of 15 cc. to 20 cc. of medium. Manometric cholangiography, in spite of its lengthening the time of surgery, does serve to render a better appreciation of the range of normal intraductal pressures in correlation with the cholangiograms. Once this is understood the actual manometry may not be mandatory. In those institutions wherein personnel functioned as a team to eliminate existing problems, the procedure has been accepted as a necessary adjunct for adequate surgery of the biliary tract.

The key to satisfactory examination is close teamwork so that adequate diagnostic films are available. This having been accomplished, there remains the last hurdle of interpreting the films. Naturally, it is not reasonable to expect a comparatively new procedure to be mastered within a short time; patience and infinite care are required. To state that this or any x-ray procedure is without error would be an evasion of truth, and it has been found in many instances that errors made were not in the procedure but rather in inexperience in interpreting the films.

The chief source of error, particularly in the hands of the neophyte, is in the presence of air bubbles. It does not take long, however, to learn to maintain a closed system and, if an air bubble is present, in most instances how to differentiate

Submitted for publication May 27, 1955.

* "Operative cholangiography" is herein interpreted to mean both the operative and control operative cholangiography. "Operative cholangiography" is the demonstration of the bile duct prior to the exploration of the common duct. "Control Operative cholangiography" is done in surgery after exploration of the common duct to be sure that all calculi have been removed before the patient leaves the operating room.

it from a calculus. Inexperience in inserting the needle or catheter into the cystic or common duct may result in unsatisfactory cholangiograms. If the cholangiogram is unsatisfactory, then the procedure should be redone correctly, immediately. This can be accomplished with little loss of time. Granted that occasionally there may be a false positive diagnosis with a negative exploration of the common duct, the number of common ducts explored on the basis of operative cholangiograms is far less than those explored on the basis of clinical data or operative findings.

With operative cholangiography the incidence of unnecessary exploration of the common duct can be reduced from 45% or 50% to 4% or 5%. Furthermore, the incidence of subsequent common duct calculi has been reduced from 16% to 25% to 4%. The accuracy of probing and palpating the distal common duct has been questioned by a number of surgeons. Numerous instances can be cited of common duct calculi being bypassed with probes or a stenosed sphincter of Oddi being pushed by a probe into the duodenum and, therefore, the common duct considered to be patent. Sometimes the surgeon may believe the common duct to be dilated only to find by cholangiography that it is really a small common duct surrounded by a periductal fibrosis. Furthermore, and this is important, particularly in a poor operative risk patient, a negative operative cholangiogram can eliminate unnecessary prolonged surgery.

There is universal agreement as to the value of postoperative cholangiography. The equivalent results are obtainable with operative cholangiography. There should be no question as to the value of the procedure. Not only does cholangiography serve in the detection of unsuspected calculi but also it prevents additional surgery by enabling the operator to identify a noncalculus lesion, such as spasm or fibrosis, pancreatitis, carcinoma, polyps, and sometimes, unfortunately, surgical sequelae.

Perhaps it is well to repeat the thought that for such a procedure to be successful and for its use to be continued complete cooperation of the entire team is required. By their working together carefully and confidently, incidental mistakes can be overcome and the relatively high incidence of poor results following biliary surgery can be reduced.

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Surgery Illustrated

A TECHNIQUE OF CHOLEDOCHOSTOMY

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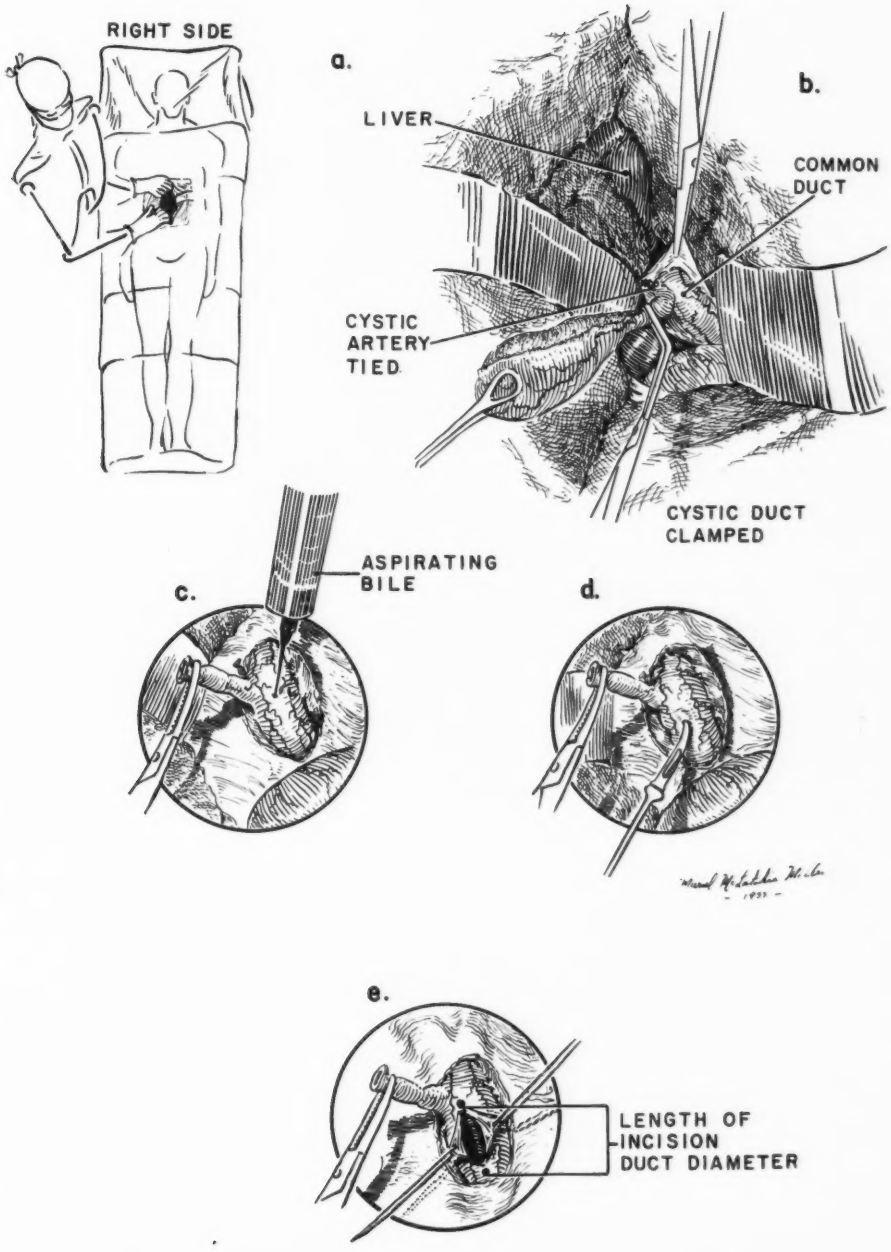
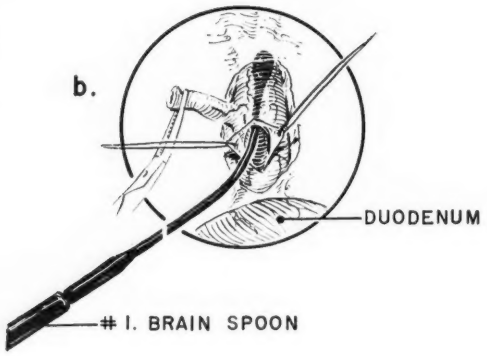
Boston

At this time there is considerable controversy throughout the surgical world regarding routine cholangiography on the operating table. There is, without doubt, an occasional need for such a procedure, which makes it justifiable for every large hospital to have the necessary equipment available. It is apparent, however, that the routine use of this method is a cumbersome and impracticable solution to the problem of diagnosis and treatment of stones in the biliary ducts.

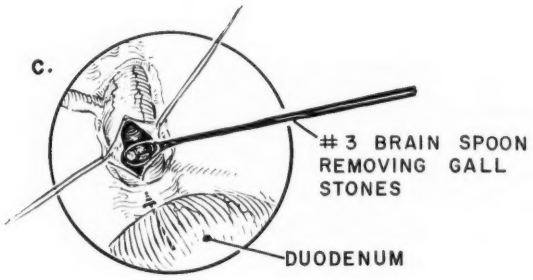
The illustrations which are here shown reveal a technique satisfactorily in use at the Massachusetts General Hospital for the past quarter of a century. That all methods of searching and flushing the ducts failed in many instances was due to the inability to remove stones hidden within the intrahepatic ramifications of the ductal system. Thus the late Czechoslovakian surgeon, J. Bakeš [1] practicing in Vienna, conceived the idea of gradual instrumental dilatation of the papilla of Vater. He revealed the fact that this could be accomplished without injury to the patient and that stones left within the liver ducts would pass through the dilated outlet. After exploration of the common hepatic duct and removal of the available calculi, the papilla was gently stretched by dilators from the normal 3 mm. to a size just below the diameter of the common duct. This dilatation rarely needs to go beyond 7 mm., but it can be carried further safely if the duct is very large. The basis of this instrumentation is that the diameters of the hepatic ducts are necessarily less than that of the common duct. The papilla is not actually a sphincter muscle, and reflux of duodenal contents is prevented by an overlap of the mucous membrane which acts as a flap valve. Also, the oblique musculature around the papilla regains its erectile properties after instrumentation. Not only has this technique reduced to a minimum the necessity of late operations for overlooked or recurrent stones, but it has also proved useful in many cases of stricture of the papilla with accompanying chronic relapsing pancreatitis.

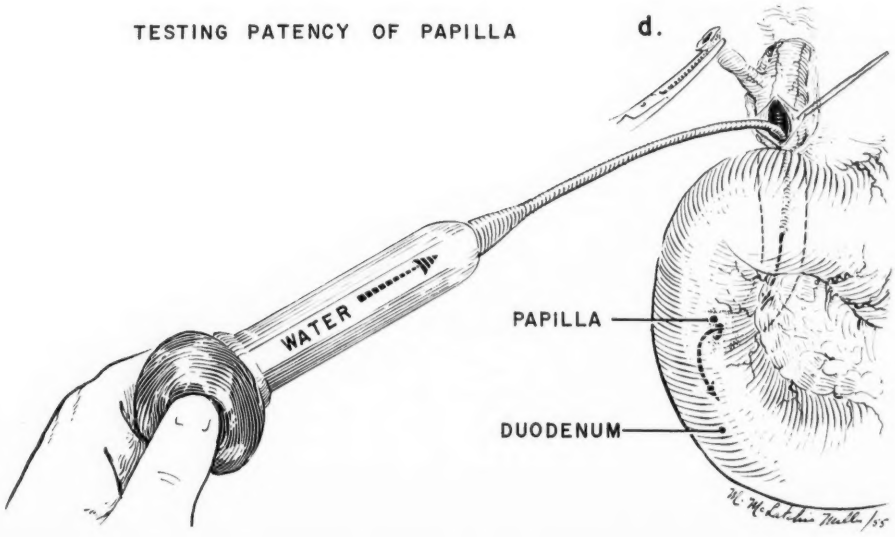
After the common duct is exposed, aspirated, and incised, the lips of the incision are held open with silk guy sutures. Exploration of the ducts can be started from the right side of the patient. The Cushing brain spoons are malleable and have rounded edges and thus prevent injury to the duct lining. The diameter of the ducts can be measured with the Bakeš dilators. By going to the patient's left side, the surgeon can palpate the ductal system more accurately. With the fingers of the left hand in the foramen of Winslow and with the thumb on anterior surface, the instruments can be guided without danger of making false passages. Dilators should be used with care and gentleness. They are accurately graduated so that each successive dilator increases the diameter of the papilla by 1 mm. Actual strictures within the duct can rarely be safely stretched. This, however, does not apply to the papilla.

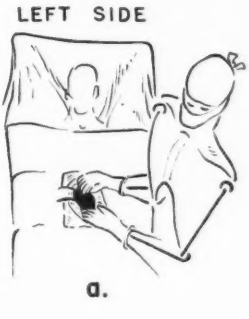

RIGHT SIDE
a.
b.
LIVER
COMMON DUCT
CYSTIC ARTERY TIED
CYSTIC DUCT CLAMPED
c.
ASPIRATING BILE
d.
e.
LENGTH OF INCISION
DUCT DIAMETER

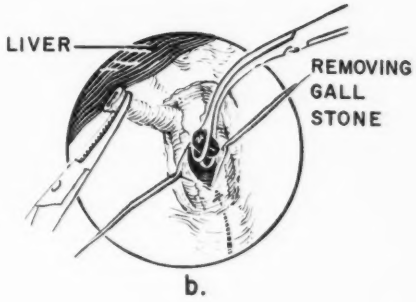

b.
DUODENUM
I. BRAIN SPOON

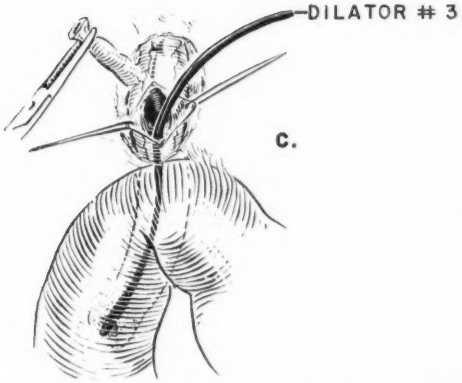
LEFT SIDE
a.

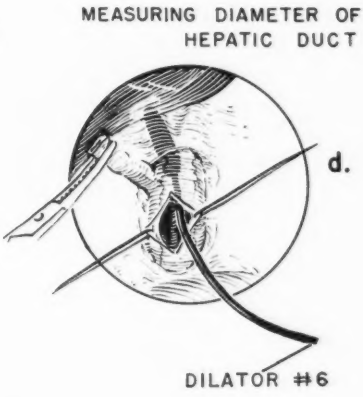

c.
3 BRAIN SPOON
REMOVING GALL
STONES
DUODENUM

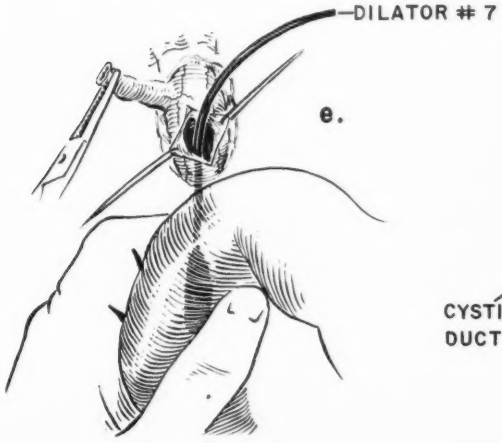

TESTING PATENCY OF PAPILLA
d.
WATER
PAPILLA
DUODENUM


LEFT SIDE
a.


LIVER
REMOVING GALL STONE
b.


DILATOR # 3
c.


MEASURING DIAMETER OF HEPATIC DUCT
d.
DILATOR #6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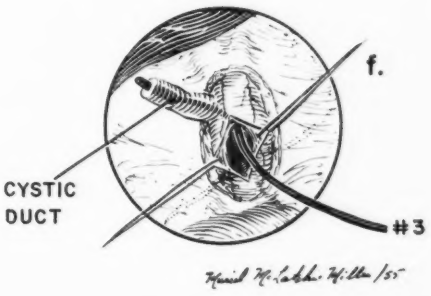
e.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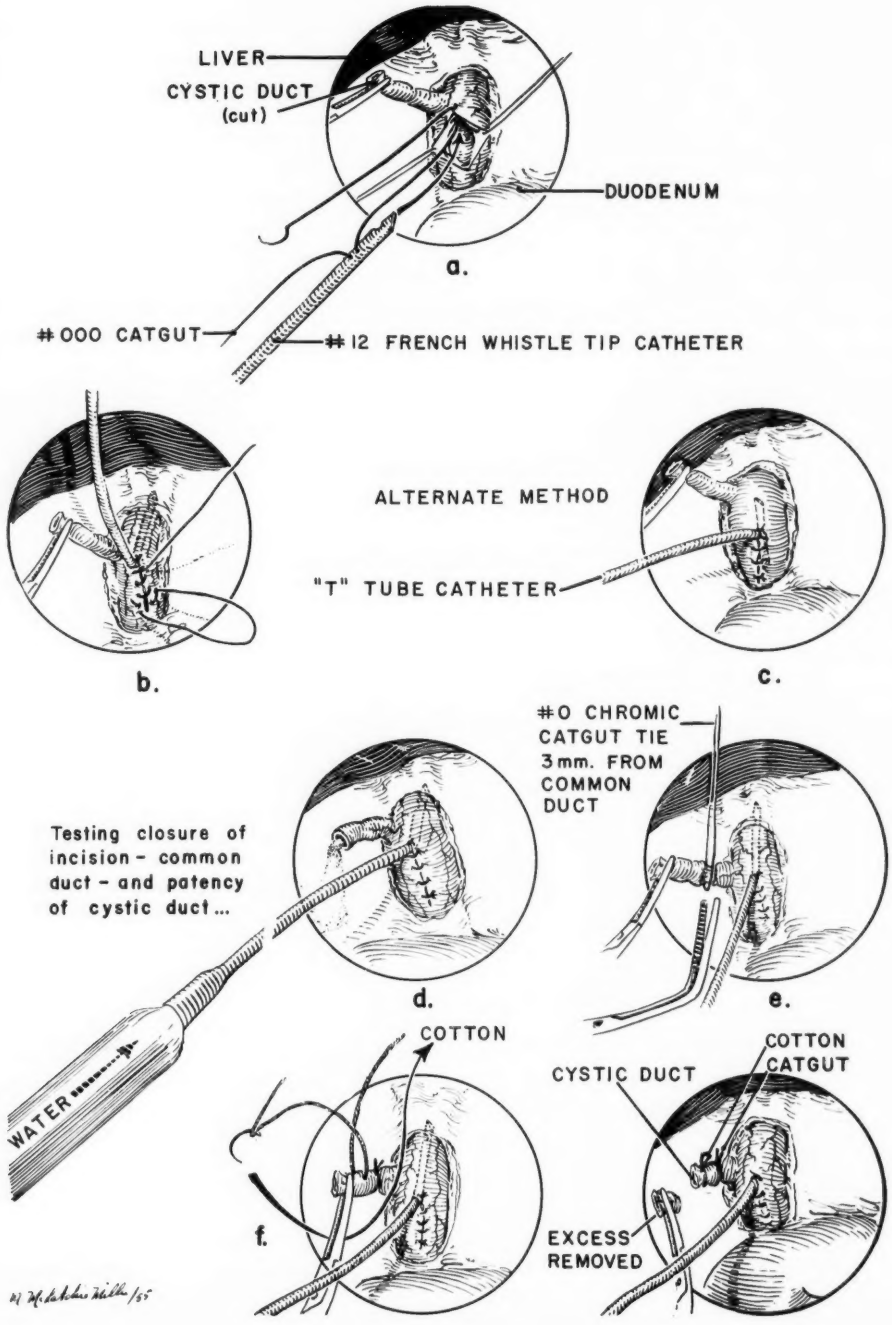
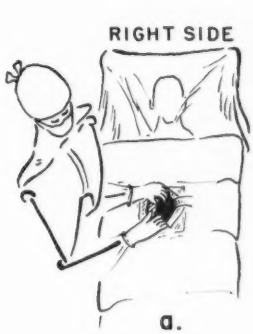
CYSTIC DUCT
#3


LIVER
CYSTIC DUCT
(cut)
DUODENUM
a.
#000 CATGUT
#12 FRENCH WHISTLE TIP CATHETER
b.
ALTERNATE METHOD
"T" TUBE CATHETER
c.
#0 CHROMIC
CATGUT TIE
3mm. FROM
COMMON
DUCT
Testing closure of
incision - common
duct - and patency
of cystic duct...
d.
e.
WATER
COTTON
f.
COTTON
CATGUT
CYSTIC DUCT
EXCESS
REMOVED



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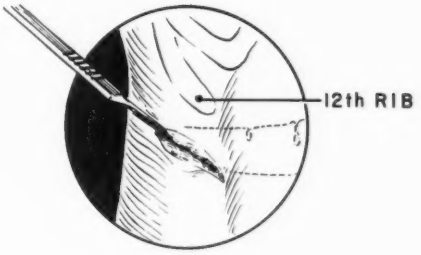

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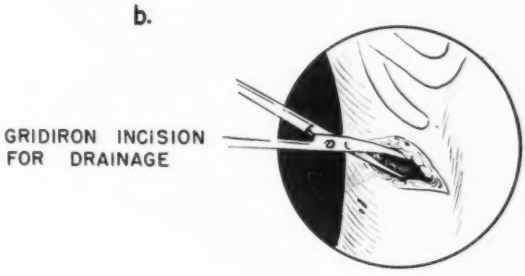

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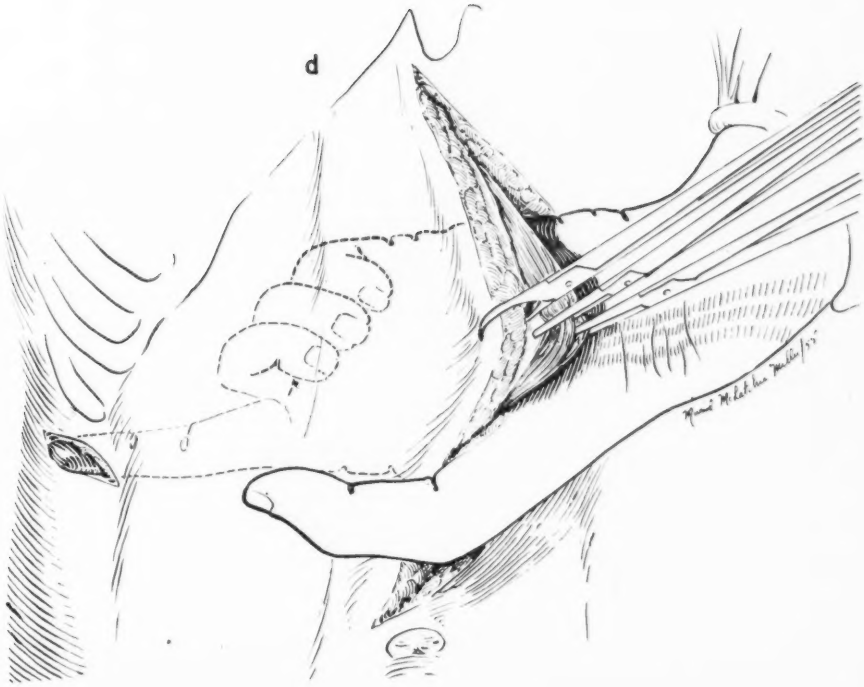
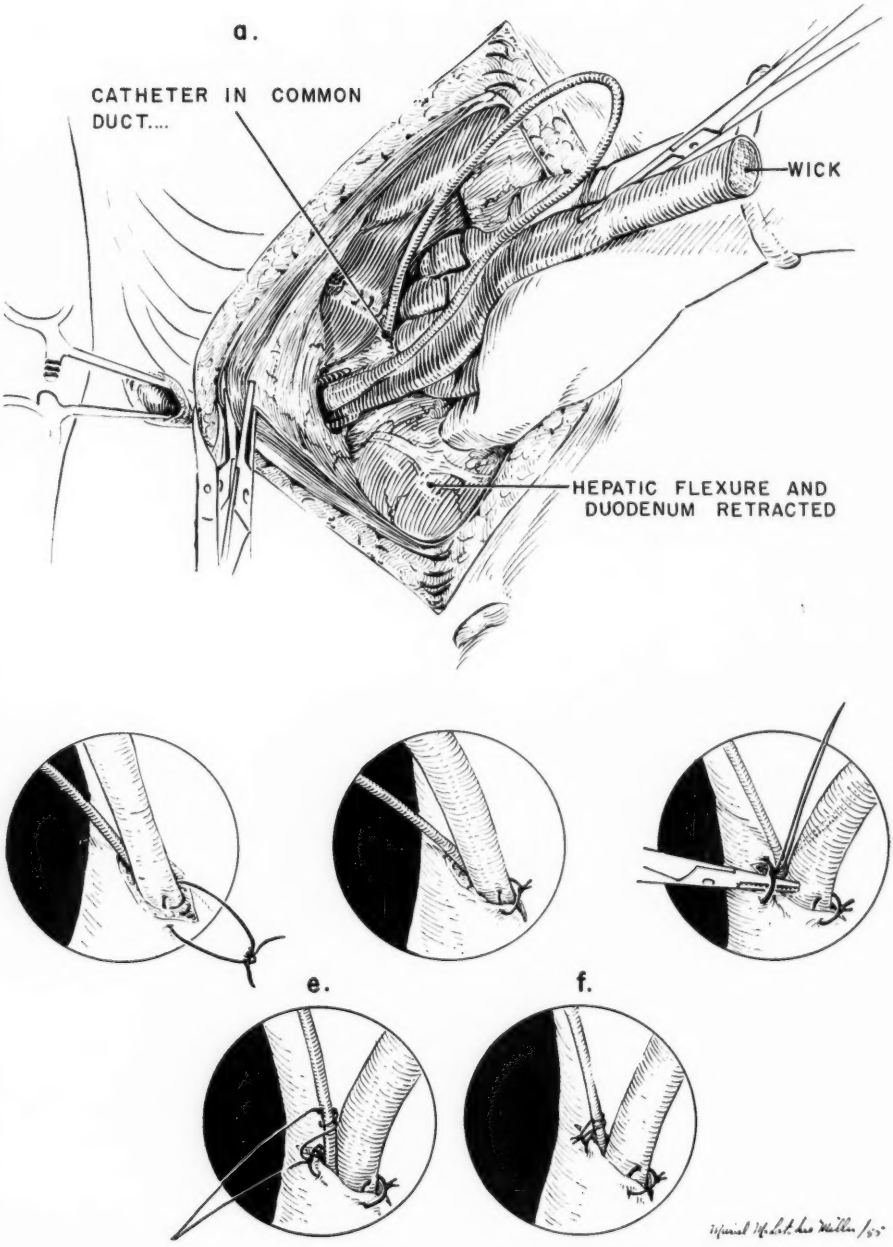
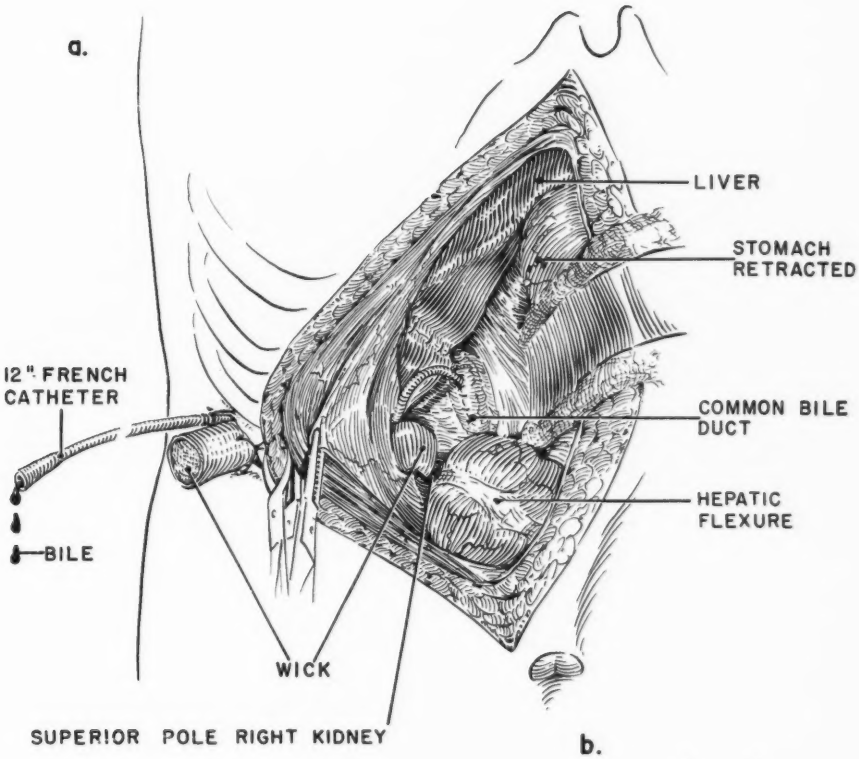
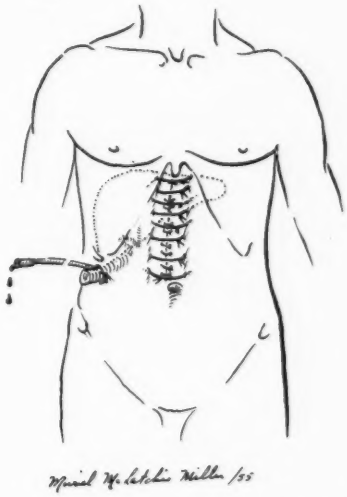


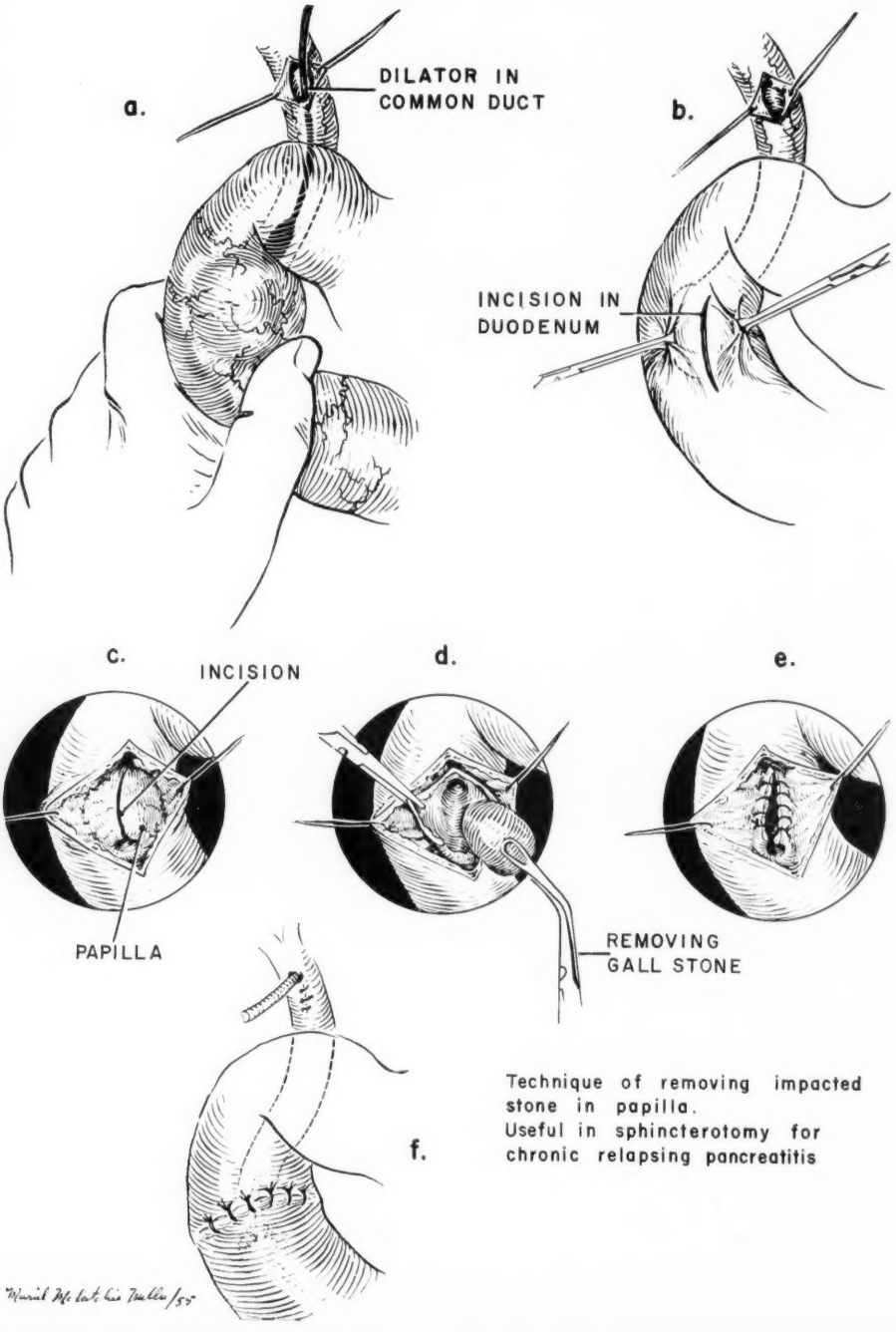

a.
CATHETER IN COMMON DUCT....
WICK
HEPATIC FLEXURE AND DUODENUM RETRACTED
e.
f.



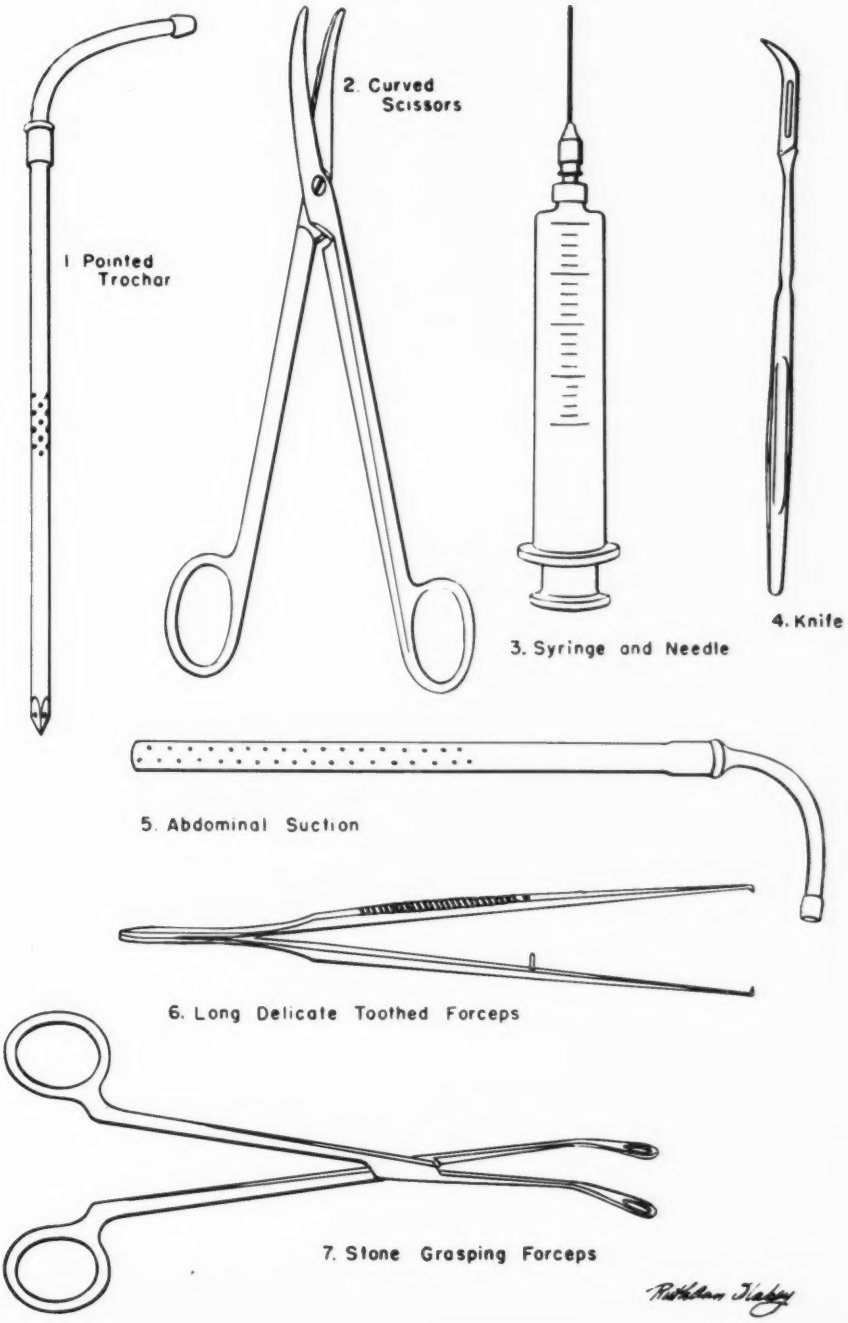
Note slack in common duct tube. The cigarette wick is short, ending in Morrison's pouch which is the bottom of the "water shed".

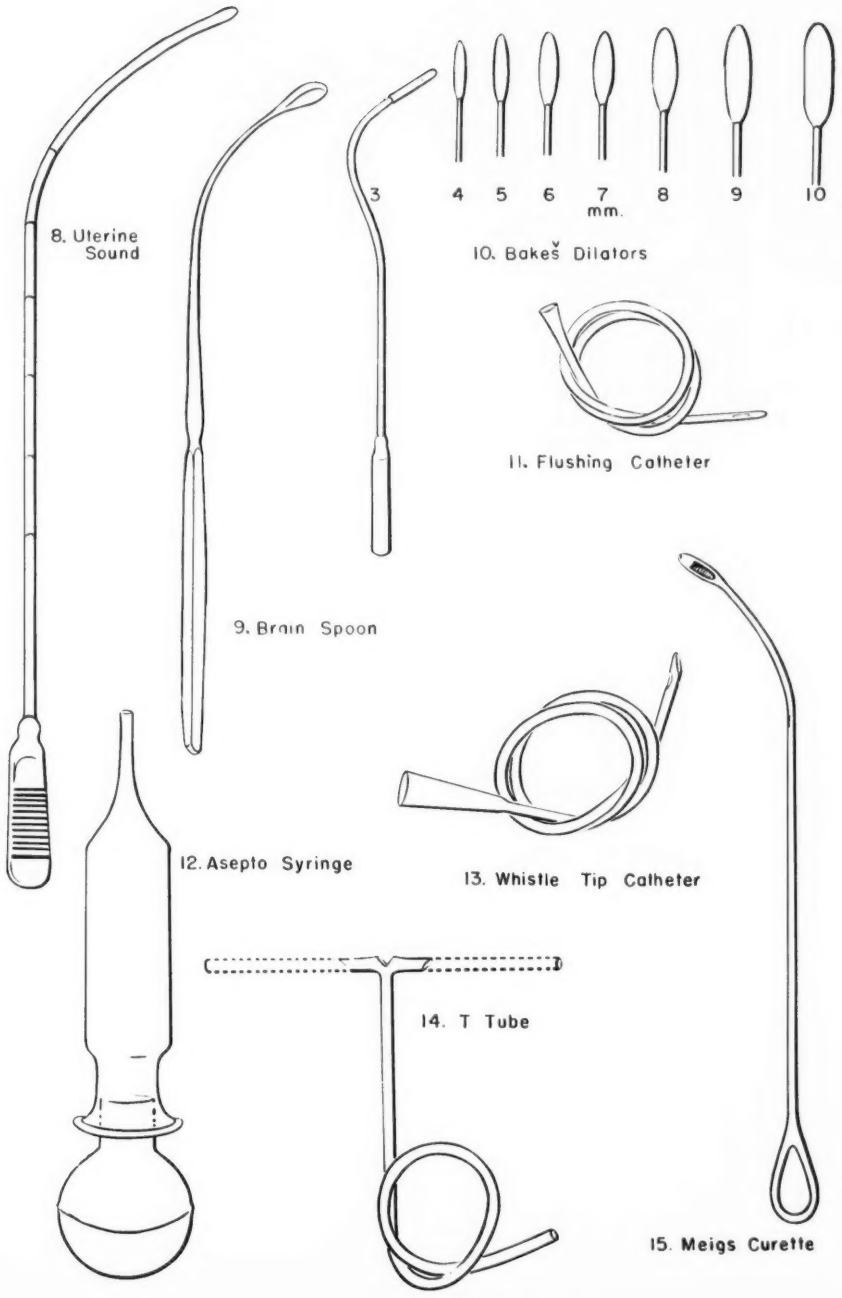


Muriel McLatchie Miller /55



Technique of removing impacted stone in papilla.
Useful in sphincterotomy for chronic relapsing pancreatitis


1. Pointed Trochar
2. Curved Scissors
3. Syringe and Needle
4. Knife
5. Abdominal Suction
6. Long Delicate Toothed Forceps
7. Stone Grasping Forceps


8. Uterine Sound
3
4 5 6 7 8 9 10
mm.
10. Bakeš Dilators
11. Flushing Catheter
9. Brain Spoon
12. Asepto Syringe
13. Whistle Tip Catheter
14. T Tube
15. Meigs Curette

The Meigs endometrial biopsy curette has made it possible for me to make a correct diagnosis of carcinoma of the papilla in four instances. The chief caution in the use of these instruments is to have malleable handles, adequate exposure, and proper tactile guidance. The duct can at times be easily torn. It is not wise to force the dilators through the pancreatic portion of the duct if acute or subacute pancreatitis is evident. If reasonable care is used, the routine technique herein depicted does not increase morbidity or mortality.

In 1940, a colleague and I reported [2] that of 561 patients who had had the papilla dilated, only 4, or 0.71%, returned for recurrent common duct stones. In a parallel group of 214 patients in the same hospital with common duct exploration without dilatation of the papilla, 9, or 4.21%, returned with common duct stones. Claude E. Welch, using the technique herein described, reported that he had made 100 consecutive postoperative cholangiograms and found only one overlooked stone. Of these 100 cases, all had stones in the gall bladder or ducts and 53 had stones in the ducts.

Considering the percentage of error in operative cholangiography and the many difficulties associated with the procedure, it would seem to me that routine use of this method is unjustified.

REFERENCES

1. Bakeš, J.: On Drainageless Surgery of the Bile Passages and on the Methodical Dilatation of the Papilla, Zentralbl. Chir. **55**:858-868, 1928.

2. Allen, A. W., and Wallace, R. H.: The Surgical Management of Stone in the Common Bile Duct, Ann. Surg. **111**:838-847, 1940.

Scientific Exhibits

CHRONIC RELAPSING PANCREATITIS

RICHARD B. CATTELL, M.D.
AND
KENNETH W. WARREN, M.D.
Boston

Clinical Recognition

SYMPTOMS

PAIN
NAUSEA AND VOMITING
DIARRHEA, STEATORRHEA
WEIGHT LOSS
JAUNDICE

DIAGNOSTIC AIDS

ELEVATED SERUM AMYLASE
GLUCOSE TOLERANCE
STARCH TOLERANCE
STOOL ANALYSIS
SECRETIN TEST
X-RAY

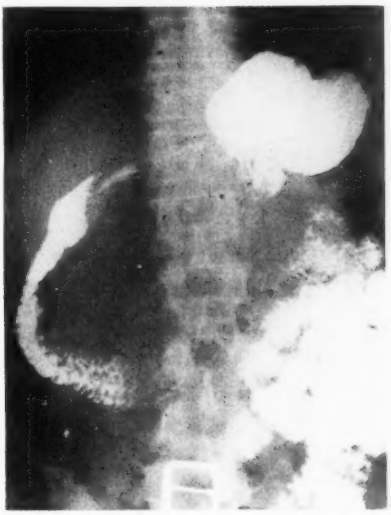
CLINICAL FEATURES
IN 90 OPERATIVE CASES

ABDOMINAL PAIN	100%
WEIGHT LOSS	94
ALCOHOLIC ABUSE	56
NARCOTIC USE	48
PANCREATOLITHIASIS	41
DIABETES MELLITUS	38
JAUNDICE	25
PANCREATIC CYSTS	25

X-RAY DATA

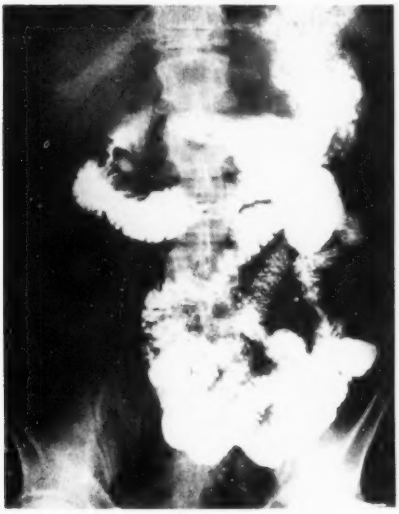
- EXCLUSION OF OTHER GASTROINTESTINAL DISEASE
- DISTORTION OF DUODENUM
- OBSTRUCTION OF PYLORUS OR DUODENUM
- NARROWING OF INTRAPANCREATIC PORTION OF THE COMMON BILE DUCT
- PANCREATOLITHIASIS

Shown as a scientific exhibit of the Section on Surgery, General and Abdominal, at the 104th Annual Meeting of the American Medical Association, Atlantic City, June 6-10, 1955.



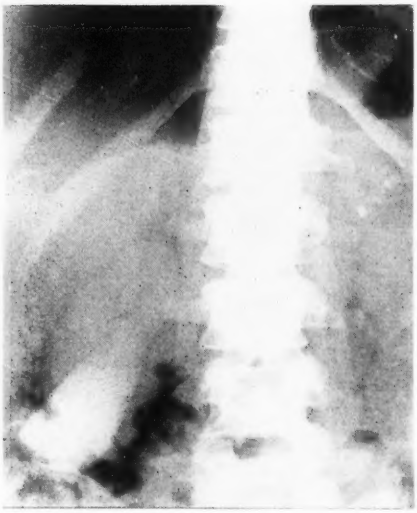
Wide duodenal sweep with pressure on antrum and duodenum.

Distortion and partial obstruction of duodenum.

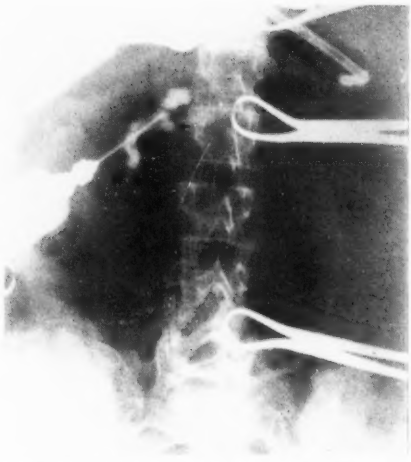


Large pancreatic calculus in duct of Wirsung near ampulla of Vater.

Multiple calculi involving entire gland.

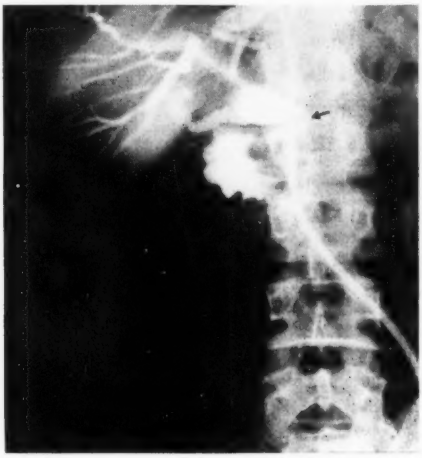


Pancreatolithiasis confined to distal segment of pancreas.



Operative injection of iodopyracet (Diodrast). Two points of obstruction of duct of Wirsung by pancreatic calculi (arrows).

Iodopyracet injection of pancreatic fistula showing distal ductal system and residual cystic cavity.



Cholangiogram showing incomplete stricture (arrow) of distal common duct from pressure of enlarged head of pancreas.

Illustrative Cases

CASE HISTORY

FEMALE — AGE 44

ABDOMINAL PAIN 2 YEARS

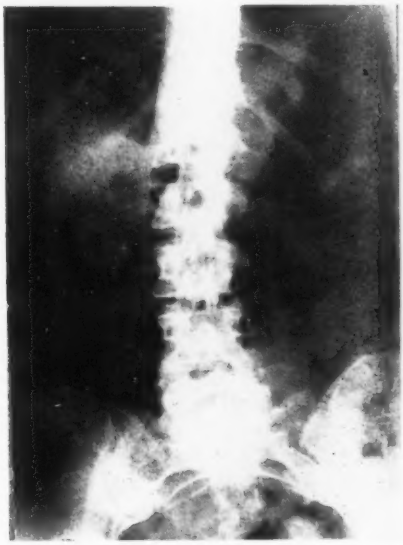
CHOLELITHIASIS, DIABETES MELLITUS, PANCREATOLITHIASIS

DISTAL PANCREATECTOMY. COMPLETE RELIEF FROM PAIN

RESECTION TONGUE AND RADICAL NECK DISSECTION FOR CARCINOMA (MARCH 1955)

Multiple calculi in body and tail of pancreas.

Cavity in obstructed duct of Wirsung and site of spontaneous pancreatogastric fistula.



Postoperative flat plate of abdomen showing absence of pancreatic calculi.

CASE HISTORY

FEMALE—AGE 55

ABDOMINAL EXPLORATION ELSEWHERE FOR ACUTE PANCREATITIS (1947)

CONTINUOUS SYMPTOMS

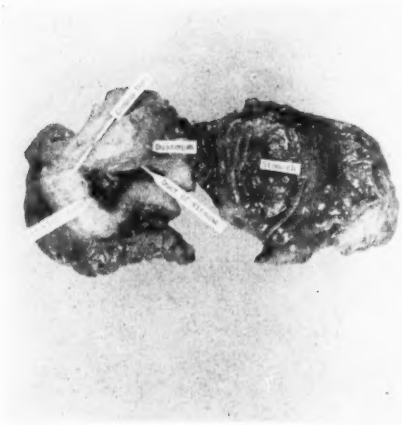
NARCOTIC USE, NO ALCOHOL

DIABETES MELLITUS, PANCREATOLITHIASIS

PANCREATODUODENECTOMY MARCH 1951. COMPLETE RELIEF OF SYMPTOMS

EXPIRED APRIL 1954. CAUSE UNKNOWN

Multiple calculi in head and body of pancreas.



Cystic cavity in head of pancreas containing numerous calculi. Duct of Wirsung completely obstructed distal to ampulla of Vater.

Postoperative roentgenogram of stomach.

CASE HISTORY

MALE—AGE 43

ABDOMINAL PAIN 7 YEARS

ALCOHOLIC ABUSE, NARCOTIC USE

DIABETES MELLITUS

SERUM AMYLASE 150–800 UNITS

SPHINCTEROTOMY ELSEWHERE WITHOUT RELIEF

PANCREATODUODENECTOMY APRIL 10, 1954.
PROGRESS EXCELLENT

Multiple calculi in head of pancreas. Indentation of duodenum at site of previous duodenotomy.

Specimen showing fibrosis and multiple cysts.

Radiogram of iodopyracet-injected specimen showing complete obstruction of duct of Wirsung near ampulla of Vater.

CASE HISTORY

FEMALE– AGE 35

ABDOMINAL PAIN 13 MONTHS

DRAINAGE PANCREATIC CYST FEBRUARY 8, 1951

SPHINCTEROTOMY MARCH 1951

DIABETES MELLITUS, PANCREATOLITHIASIS, NARCOTIC USE

TOTAL PANCREATECTOMY FEBRUARY 1, 1952. RELIEF OF PAIN

RESECTION JEJUNAL ULCER JANUARY 1954. EXCELLENT RESULT

Preoperative x-ray of abdomen showing pancreatic calculi.

Specimen showing dilated duct of Wirsung containing numerous calculi.

Roentgenogram two years later showing gastrojejunal ulcer (arrow).

Surgical Treatment

INDIRECT

A. BILIARY TRACT PROCEDURES
1. CHOLECYSTECTOMY – CHOLEDOCHOSTOMY
2. BILIARY–INTESTINAL ANASTOMOSIS
3. SPHINCTEROTOMY

B. GASTROINTESTINAL DIVERSION
1. GASTROENTEROSTOMY
2. PYLORIC EXCLUSION
3. GASTRECTOMY

C. NERVE INTERRUPTION
1. SYMPATHECTOMY
   a. Thoracolumbar
   b. Splanchnicectomy
2. VAGOTOMY

DIRECT

A. DRAINAGE OF CYSTS

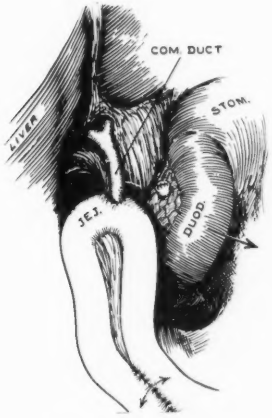
B. LITHOTOMY

C. ANASTOMOSIS OF DUCT OF WIRSUNG
1. CONTINUITY
2. DIVERSION

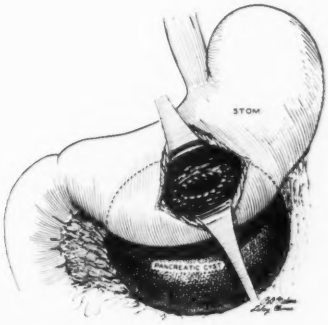
D. TRANSDUODENAL EXPLORATION AND DILATATION OF PANCREATIC DUCTS

E. RESECTIONS
1. DISTAL PANCREATECTOMY
   a. Distal pancreatectomy with pancreatojejunostomy
2. PANCREATODUODENECTOMY
3. TOTAL PANCREATECTOMY

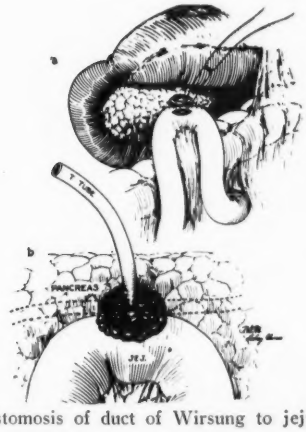
SURGICAL TECHNIQUE



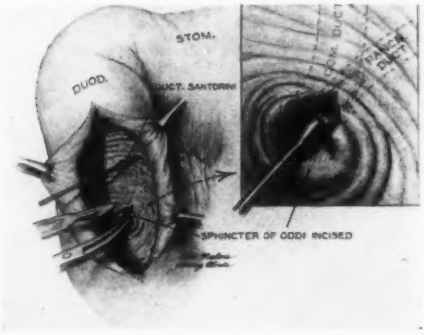
Choledochojejunostomy.



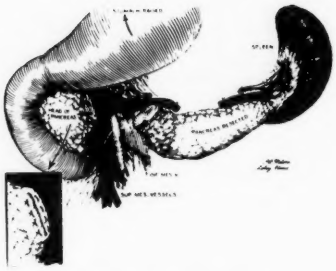
Transgastric cystogastrostomy.



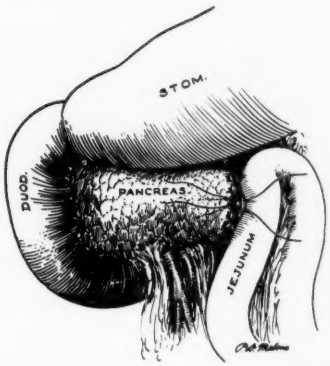
Anastomosis of duct of Wirsung to jejunum.



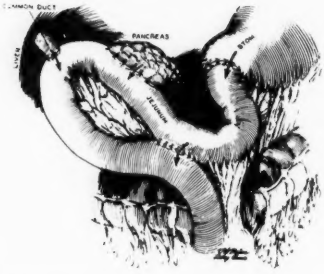
Transduodenal dilatation of ducts of Wirsung and Santorini.



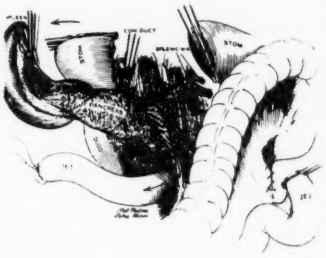
Distal pancreatectomy.



Distal pancreatectomy with retrograde pancreatojejunostomy.



Reconstruction following pancreatoduodenectomy.



Total pancreatectomy.

TYPES OF OPERATION

EXPLORATORY CHOLEDOCHOSTOMY	5
DRAINAGE OF PANCREATIC CYSTS	7
CHOLEDOCHOJEJUNOSTOMY	1
GASTROENTEROSTOMY AND VAGOTOMY	1
GASTROENTEROSTOMY	1
SPHINCTEROTOMY	10
UNILATERAL THORACOLUMBAR SYMPATHECTOMY	4
BILATERAL THORACOLUMBAR SYMPATHECTOMY	5
PYLORIC EXCLUSION AND CHOLEDOCHODUODENOSTOMY	1
GASTRECTOMY	1
DISTAL PANCREATECTOMY	10
PANCREATOGASTROSTOMY	5
PANCREATOJEJUNOSTOMY	2
DILATATION OF PANCREATIC DUCTS	20
PANCREATODUODENECTOMY	13
TOTAL PANCREATECTOMY	1
TOTAL	87

CONCLUSIONS

- TRANSDUODENAL EXPLORATION DUCTS OF WIRSUNG AND SANTORINI IN EARLY CASES. DIVERSION OF COMMON DUCT WHEN OBSTRUCTED
- ANASTOMOSIS DUCT OF WIRSUNG TO JEJUNUM IN PERSISTENT FISTULAS ARISING IN HEAD OR NECK OF PANCREAS
- DISTAL PANCREATECTOMY FOR DISEASE CONFINED TO DISTAL SEGMENT. ALSO FOR TRAUMATIC FRACTURE OF THE GLAND
- PANCREATODUODENECTOMY FOR ADVANCED DISEASE WITH MULTIPLE POINTS OF OBSTRUCTION OF PANCREATIC DUCTS
- TOTAL PANCREATECTOMY WHEN OTHER MEASURES FAIL